GEOTECHNICAL RECONNAISSANCE

Stevens Creek

SAN FRANCISCO BAY TO HOMESTEAD ROAD
SANTA CLARA COUNTY, CALIFORNIA

STEVENS CREEK COMPREHENSIVE
USE AND MANAGEMENT PLAN STUDY

TO: SANTA CLARA VALLEY WATER DISTRICT
SAN JOSE, CALIFORNIA

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145 Addison Avenue, Palo Alto, California 94301 415/328-6920

May 5, 1978
109-10, PA8250

Santa Clara Valley Water District
5750 Almaden Expressway
San Jose, California

Attention: Mr. Stan Wolfe

RE: GEOTECHNICAL RECONNAISSANCE
STEVENS CREEK COMPREHENSIVE
USE AND MANAGEMENT
PLAN STUDY
MOUNTAIN VIEW, CALIFORNIA

Gentlemen:

In accordance with your request, we have performed a geotechnical reconnaissance of Stevens Creek for the above project. The accompanying report presents the results of our field investigation, geologic and engineering analyses. The geologic conditions are discussed and recommendations for the engineering geology aspects of the project are presented.

We refer you to the text of the report for detailed results and recommendations. If you have any questions concerning our findings, please call.

Very truly yours,

JOHN V. LOWNEY & ASSOCIATES

John V. Lowney

John V. Lowney
Registered Engineer

Donald R. Fowler

Donald R. Fowler
Registered Geologist

JVL/DRF:ch

Copies: Addressee

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TO: SANTA CLARA VALLEY WATER DISTRICT
SAN JOSE, CALIFORNIA

1.4.522

John V. Lowney & Associates
Foundation/Soil/Geological Engineers

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GEOTECHNICAL RECONNAISSANCE
STEVENS CREEK
SAN FRANCISCO BAY TO HOMESTEAD ROAD

INTRODUCTION

In this report, we present the results of our geotechnical reconnaissance of Stevens Creek located in the northwestern part of Santa Clara County in the cities of Mountain View, Los Altos, and Sunnyvale, California. The lower part of the stream, from Homestead Road north to San Francisco Bay constituted the reach studied. The purpose of this investigation was to evaluate the geologic conditions along the Creek, particularly slope stability, and provide recommendations for setback lines to be used in land use evaluations.

SCOPE

The scope of work performed in this investigation included a field reconnaissance with geologic mapping of the study area, a review of pertinent geologic and engineering literature, air photo interpretation, analysis of the field data, and the preparation of this report.

The investigation was conducted under the direction and review of John V. Lowney, Civil Engineer. Review of the findings and recommendations presented in this report were the responsibilities of Dale G. Wilder, Civil Engineer and Geologist. Field and office geology and geologic analyses were performed by Donald R. Fowler, Registered Geologist.

AREA GEOLOGY

Stevens Creek flows in a northerly direction from the Santa Cruz Mountains, across an alluvial fan, to San Francisco Bay, as shown on the Site Plan, Figure 1.

fragments. The mud is blue gray to black in color, and contains abundant organic matter. It is soft and plastic throughout, although where exposed to the air behind levees, a firm crust several feet thick with large dessication cracks will develop.

The study area has generally well developed soils combined into three subgroups based on geographic location, soil drainage, and original sediments. The largest area from Homestead Road to Central Avenue is dominated by moderately well to somewhat excessively drained, medium to fine textured soils of the alluvial plains and fans. These soils are used for irrigated row crops, orchards, dryland hay and pasture, and include the most productive soils in the Santa Clara Valley. Erosion is not usually a problem except along drainage channels.

The area from Central Avenue to Crittenden Lane is dominated by very deep, level, somewhat poor to poorly drained soils. These soils are used for irrigated row crops, sugar beets, orchards, dryland grain, hay and pasture. The fine texture and slow permeability creates severe limitations for septic tank filter fields. Shrink-swell behavior is moderate to high.

The area from Crittenden Lane to San Francisco Bay is dominated by fine textured soils influenced by tidal water. These soils are affected by high concentrations of salts, and are used for limited pasture, wildlife, recreation and salt ponds. The soils are flooded at high tide when not protected by levees.

B. Groundwater

Generally the water table is moderately deep in the southern part of the study area, and gradually nearing the surface in the north. The depths to groundwater between Homestead Road and Central Avenue range from as shallow as 24 feet to as deep as 80 feet in the alluvial fan deposits. From Central Avenue to Crittenden Lane, depth to groundwater varies from 4 feet to 17 feet in the fluvial deposits. Adjacent to the Bay, groundwater is very near the surface and ranges from 1 foot to 5 feet in depth. Part of the variability within each subarea may be related to seasonal changes (Rodgers and Williams, 1974).

Up until approximately 1968, much of the land in the study area underwent subsidence due to groundwater withdrawal (Poland, 1971 and 1976). The artesian head declined 180 to 250 feet and the land surface subsidence amounted to approximately 6.5 feet near the Bayshore Freeway, with decreasing amounts to the north and south. The subsidence was caused by the decline of the artesian head and the resulting increase in effective overburden load on the water-bearing beds in the confined system. The sediments compressed under the increasing stress and the land surface sank. Most of the compression occurred in the fine grained clayey beds (aquitards) as their pore water pressures decreased.

Since 1967, the artesian head has recovered about 100 feet due to an increase of surface water imports, favorable local water supply, decreased groundwater withdrawal, and increased recharge. The subsidence has stopped throughout the system. However, subsidence would likely re-occur if the artesian head is drawn down appreciably below the levels of 1971-1973. The drought of the last two years did not reportedly cause any additional subsidence.

The regional subsidence resulted in alteration of the Stevens Creek stream gradient causing filling of the depressed stream channel with sediment. The flood control levees between Bayshore Freeway and San Francisco Bay were originally needed to protect subsiding areas from flooding. Since the subsidence is regional, it has not caused differential settlement foundation problems for individual structures in the study area.

C. Faults and Seismicity

Santa Clara Valley is bounded on the east and west by active fault zones, the Hayward, Calavaras and San Andreas, as shown in Figure 3, Regional Fault Map. In addition, there are less well understood faults projected under the alluvial valley floor. The San Andreas Fault Zone is located 5 miles southwest of the intersection of Stevens Creek and Homestead Road. There are two active faults, the Hayward and Calaveras which are located 8 and 13 miles, respectively, northeast of the mouth of Stevens Creek at the Bay.

The Sargent-Berrocal Thrust Fault, with several mapped strands, is located in the foothills of the Santa Cruz Mountains. The closest strand is located 1.5 miles southwest of the study area at Homestead Road. This fault shows some evidence of Quaternary movement (McLaughlin, 1974), and should be considered potentially active.

Recent investigations of gravel aquifers in the subsurface of Santa Clara Valley by the Division of Water Resources indicate a number of concealed faults (Ford, 1975). Based on water well data, two normal faults intersect Stevens Creek: The Santa Clara Fault crosses Stevens Creek near Franklin Avenue, as shown on Strip Map 3, and the Cascade Fault crosses the creek about half-way between Fremont Avenue and Homestead Road, as shown on Strip Map 1. The potential for activity of these faults is unknown.

Santa Clara Valley is in a seismically active area and has been affected by a large number of earthquakes, most of which were associated with the San Andreas, Hayward and Calaveras Faults. The maximum credible earthquake which could affect the study area would be 8.3 Richter Magnitude on the San Andreas Fault (Greensfelder, 1974). The study area would likely be subjected to strong groundshaking in the event of a moderate to severe earthquake. Other potential seismic hazards include liquefaction, seismically induced landslides, and inundation.

In 1906, the study area was subjected to very strong shaking as described by the Report of the California Earthquake Commission. In Mountain View, large numbers of chimneys collapsed as did about half of the water tanks. Bridges across Stevens Creek were not damaged. At least one large landslide occurred on Stevens Creek upstream of the study area. The study area was subjected to earthquake intensities of VII to VIII on the Modified Mercalli Intensity Scale which is based on observed earthquake damage.

Intensity of groundshaking is controlled by a number of factors including magnitude of earthquake, distance from earthquake epicenter and fault, and rock and soil types and distribution. Borcherdt, Gibbs, and Lajoie (1975) have compared intensities for the 1906 earthquake with different geologic units and developed a map of predicted maximum earthquake intensity in the San Francisco Bay Region. According to their work, the study area would be subjected to groundshaking intensities from strong to very strong depending on the geologic units. In general, the older, denser alluvial fan deposits from Homestead Road to Central Avenue would be subjected to strong groundshaking and the younger, less dense alluvial deposits and soft Bay Mud would be subjected to very strong groundshaking.

Liquefaction is defined as the transformation of a granular material from a solid state to a liquefied state as a consequence of increased pore-water pressure developed during shaking. Seismic groundshaking tends to compact granular sediments, which causes a transfer of load from intergranular contacts to the interstitial pore water, thereby increasing the pore-water pressure. Liquefaction is most likely to occur in beds of loose, water-saturated, well-sorted silt and sand within 100 feet of the ground surface (Lajoie and Helley, 1975). Without detailed subsurface soils exploration, the potential for liquefaction cannot be evaluated beyond a very general, qualitative way. Geologic and engineering data indicate that liquefiable deposits exist to varying degree in all of the alluvial units.

The liquefaction potential of Bay Mud and underlying sediments, from near Crittenden Lane to San Francisco Bay, is generally low to moderate, but may be locally high where saturated clean granular layers are present in Bay Mud. Loose well-sorted sand and silt beds occur in the Quaternary alluvium but are not permanently saturated because of the fluctuating groundwater levels. From Crittenden Lane to Central Avenue, depth to groundwater varies from 4 feet to 17 feet in the finer grained alluvial deposits resulting in moderate potential for liquefaction. From Central Avenue to Homestead Road, depth to groundwater varies from 24 feet to 80 feet in the alluvial fan deposits resulting in low to moderate potential for liquefaction.

Other types of ground failure such as lateral spreading and seismically induced landslides are related to liquefaction. Lateral spreading failures occur on gentle to nearly horizontal slopes underlain by saturated, loose granular layers, and would flow towards a free surface such as an open channel. Flow landslides are failures that generally occur on moderate to steep slopes underlain by saturated, loose granular deposits. Once liquefaction has occurred, flow deformation commences and continues until the driving shear forces are reduced by slope reduction to a value less than the viscous shear resistance of the liquefied soil. When this happens, the soil stops flowing and solidifies. The potential for these types of failure in the study area are similar to that for liquefaction.

There are two types of seismically induced flooding which could affect portions of the study area. Flooding caused by the runup of tsunami waves would only affect the outer part of Reach 7, as shown on Strip Map 7. Failure of Stevens Creek Dam would result in the inundation of an area along Stevens Creek between Homestead Road and Remington and spread out to the east of Stevens Creek into Sunnyvale, as shown on Strip Maps 1 and 2.

D. Geomorphology

Stevens Creek, beginning in the Santa Cruz Mountains and flowing intermittently across an alluvial plain to San Francisco Bay, is incised into the alluvial plain with a fairly straight valley. The channel meaders across this narrow stream valley causing some undercutting of the valley walls. The first mile of stream valley north of Homestead Road averages about 20 feet deep and varies from approximately 70 to 150 feet wide. The channel generally is about 15 to 30 feet wide with a flat bed covered with loose sand, gravel, cobbles, and occasional boulders. In the next two miles the stream valley is about 40 feet deep and ranges from 80 to 200 feet wide, and one small area 300 feet wide. For the next mile from about El Camino Real to the Stevens Creek Freeway, the stream valley changes from about 30 feet deep at El Camino Real to 20 feet deep past Central Avenue, and the valley ranges from about 80 feet to 180 feet wide. The northern-most 3 miles of Stevens Creek has been altered by man for flood control purposes. From Stevens Creek Freeway to just past Bayshore Freeway, the stream valley has been channelized. The valley walls have been graded and portions of the valley straightened, and several sections have been concrete lined. North of Bayshore Freeway the creek flows between flood control levees. These range from about 100 feet apart near Moffett Field to about 200 feet apart at San Francisco Bay.

During wetter portions of the Quarternary age, Stevens Creek had greater stream flows which carried more sediments out of the Santa Cruz Mountains and formed alluvial fans. In more recent time, as the region got drier, the growth of alluvial fans ceased and Stevens Creek began to incise its channel into the alluvial fan as a result of lesser flows and decreased sediments. Streams also tend to develop a concave stream gradient where the upstream gradient is steeper than the downstream reaches. An even stream gradient is developed by erosion of the high spots and deposition in the low spots. This is one of the reasons the lower part of Stevens Creek has had some siltation to compensate for the regional subsidence due to groundwater withdrawal.

The physical morphology of Stevens Creek and its valley and the stability of the side walls are dependent on the ongoing fluvial processes of erosion and sedimentation. As water flows along the stream channel, the zone of greatest velocity tends to move towards the outside of curves, and even in a straight channel the zone of greatest velocity tends to migrate from side to side. This migration is caused by turbulent flow and irregularities in the channel. The zone of greatest velocity is also the zone of greatest erosive force, and the migration from one side to the other tends to be reinforced as first one side and then the other is eroded. This process will eventually produce a meandering stream.

While some of the least stable zones are on the outside of curves where erosion and undercutting is greatest, there are a number of other processes and factors which affect slope and channel morphology. The slope of the cross-section of a stream channel at any location is a function of the flow, the quantity and character of the sediment in movement through the section, the character of the materials making up the bed and banks of the channel, and the amount and type of vegetation on the banks.

A flowing stream only erodes its own stream channel. Other processes of mass wasting erode the valley walls and move material downslope to where it can be removed by the stream. Rapid processes would include slides and debris falls, and surface erosion and gullying by runoff of rainfall. There is also the very slow, long-term process of soil creep, a downslope movement of soil by gravity. Any of these processes can be modified and rates changed by man's action, such as removal of vegetation on slopes.

A large number of slides have occurred along the valley walls over a long period of time. Evidence of slide activity along Stevens Creek varied from fresh scarps to old, revegetated failure planes. Slides occur when the driving forces exceed the restraining forces, and more readily on steeper slopes. The different soil types along Stevens Creek have varying degrees of strength and resistance to shearing holding up the valley walls. The formation of landslides is affected by a number of factors which decrease the resistance to shear. The addition of water to soils commonly decreases their resistance to sliding; water decreases cohesive forces that bind clay minerals together, adds weight to the soils, lubricates surfaces along which slipage may occur, and reacts with some clay minerals, causing volume changes in the soil. Heavy vegetative cover, particularly trees with deep penetrating roots tend to hold surficial deposits together to increase stability. Rapid undercutting along stream courses makes slopes susceptible to landsliding. Strong ground shaking can trigger failures at the time of the earthquakes or it can jar and loosen hillside materials leading to failure at some later time.

Surface erosion and gullying of the valley walls by runoff of rainfall are also important in the shaping of Stevens Creek. Erosion of the stream banks is generally most common and rapid on the steepest slopes with little or no groundcover. Poorly controlled runoff from surrounding homes and open spaces has resulted in some well developed gullying.

E. Slope Stability

Strip Maps of Stevens Creek showing the extent and location of stable and unstable zones were compiled from geologic, soils and topographic maps, and reconnaissance field studies. The topographic maps provided information on the configuration, heights, and steepness of slopes. The geologic and soils maps provided information on the distribution of earth materials. Particular attention was given to easily erodible sand layers which could result in undercutting of the stream banks. This information was checked during the reconnaissance field studies. A detailed map of existing landslides was made with areas of active erosion and undercutting and little or no vegetation noted. A limited amount of subsurface soils information was available from test borings for bridge sites along Stevens Creek Freeway and scattered foundation investigations near the creek. The scattered test borings provided a general idea of soil types, densities and depth to groundwater. This information was used to evaluate seismic hazards such as liquefaction and lateral spreading.

The strip maps show the relative slope stability zonation and existing landslide features. The zonation maps are derivative maps intended to convey information about slope stability in a form that will be useful to the non-engineer and serve as a basis for making planning and management decisions about relative slope stability, land uses, and identifying areas where management measures are needed. This derivative map is no more precise and complete than its source materials, and is dependent on selecting and judging relative values. Since the zonation map is based on limited subsurface data, it should not be used to make specific engineering evaluations of relative slope stability of individual sites.

Four categories of relative slope stability were selected for the map:

> Category I - includes the least stable slopes varying from about 1:1 to vertical and with bare ground to moderate groundcover. This category includes areas with abundant evidence of recent slides and active erosion, and generally located on outside curves susceptible to undercutting.
>
> Category II - includes the moderately stable slopes ranging from about 2:1 to 1:1 with moderate to heavy groundcover and some evidence of older slide activity.
>
> Category III - includes the most stable areas with slopes of about 2:1 and no evidence of slope instability.

Category IV - includes relatively stable areas with man-made structures such as stone rip-rap and concrete sack rip-rap, and concrete drop structures for erosion and flood control.

The setback of each category shown on the strip maps will be discussed in the last section of this report.

SITE GEOLOGY

The Stevens Creek study areas was divided into seven reaches or zones on the basis of cultural features such as major roads. The general features of each reach are described with particular emphasis on the unstable zones.

Reach 1 - Homestead Road to Stevens Creek Freeway

This portion of Stevens Creek is characterized by a moderately incised channel averaging about 20 feet deep with fairly well developed meanders interspersed with short straight sections of stream channel, as shown in Strip Maps 1 and 2. The sidewalls generally have moderate slopes with small areas of very steep to vertical slopes, and moderate to heavy groundcover and trees. Typical cross-sections of the stream valley are shown on the Strip Maps.

This section of Stevens Creek is bounded by Sorrento Loam, a light brown to brown, friable, noncalcaceous surface soil, 6 to 15 inches deep. The subsoil extends to about 6 feet deep and is moderately permeable and slightly calcareous. Exploratory borings for the freeway encountered dense brown gravel and dense sandy silt near Homestead Road. Near Fremont Avenue, dense silty sand and dense to very dense sandy gravel were encountered. At the Stevens Creek Freeway bridge, medium dense to dense silty fine sand with gravel overlie dense to very dense sandy gravel and cobbles.

There are four sections in Reach 1 which are zoned as unstable with evidence of recent slides, and all four sections are on outside curves where erosion and undercutting is most active. The southernmost zone (designated No. 1 on Strip Map 1) has a steep slope of roughly 1:1 (horizontal to vertical) above a vertical scarp with some debris at the foot of the slope. There are a number of trees at the top of the slope, but very little groundcover. The base of the slope is unprotected. In addition, there is a partially protected drain pipe causing some undercutting of the slope.

The next three unstable zones (Nos. 2, 3 and 4) near the middle of Reach 1 have slopes which are roughly 1:1 and show evidence of landslides and are protected by large rip-rap over the lower part of the slope.

The areas zoned moderately stable have slopes varying from 1:1 to 2:1 (horizontal to vertical) have moderate to heavy groundcover and some evidence of older slides, as shown in Photographs 1, 2, and 3, Figures 4 and 5. The stable zones are located on the inside of curves, have gentle slopes of 2:1 or less, moderate to heavy groundcover and little or no evidence of instability.

Reach 2 - East Side of Stevens Creek Freeway

The southern part of this reach of Stevens Creek is similar to Reach 1 with well developed meanders, a channel depth of about 25 feet, and moderate slopes. At the second curve, there is a ten foot high drop structure with large rip-rap. North of this structure, the channel begins to change character: the stream deepens to about 36 to 40 feet, the walls are generally steeper, and slightly closer together; smaller curves and less groundcover prevails as shown on Strip Maps 2 and 3.

The soils in this section of the study area consist of Sorrento gravelly loam on the east side and Sorrento clay loam on the west side. Both of these soil types have moderate permeability, surface soils 8 to 20 inches thick, and slightly calcareous subsoils up to 4 feet thick. Borings advanced along the freeway indicate primarily medium dense to dense silty fine sands and dense sandy gravels in the southern part of Reach 2. Borings at the northern edge of Reach 2 grade slightly denser with depth. Several borings also encountered lenses of loose to firm brown silt up to 6 feet thick. These silts are easily eroded when exposed in the stream channel.

There are seven unstable zones, all of which are located on the outside of curves. The southernmost zone, (No. 5), has slopes which are roughly 1:1 with several small drywall retaining structures and small, older slumps. The zone near the drop structure (No. 6) is potentially the least stable (Photograph 4, Figure 5). The stream is undercutting the slope which is nearly 40 feet high. At the toe of the slope a 4 foot thick layer of erodable sandy gravel will require remedial action to stop the undercutting and prevent slumping. The zone to the north (No. 7) is not as unstable. The slope lies at roughly 1:1, has sparse vegetation with some bare areas, with small vertical scarps at the top of the bluff and loose soil on the slope below the scarps. There were also a few small areas with arcuate shaped tension cracks at the top of the slope. The rest of the unstable zones are smaller in area (Nos. 8, 9, 10 and 11), generally have vertical or near vertical slopes above steep talus deposits at the toe (Photographs 5 and 6, Figure 6).

The areas zoned moderately stable generally have slopes that range from 1:1 to about 2:1, have moderate groundcover and evidence of older slides. The areas zoned stable are generally located on the insides of curves with gentle 2:1 slopes and no evidence of instability.

Reach 3 - Diericx Drive to El Camino Real

At the southern edge of this reach, the stream channel makes a large, wide turn, and then tends to be much straighter with gentle curves, as shown on Strip Map 3. After the first bend with its wide, level floodplain, the channel is relatively narrow, and ranges from 30 to 36 feet deep. The side walls vary from about 1.5:1 to vertical, and range from bare slopes to those with heavy groundcover and large trees.

The soils are the same as in Reach 2 with Sorrento Clay Loam to the west of the creek, and Sorrento Gravelly Loam on the east bank. Along Dierickx Drive, the following materials were observed in test borings and stream bank exposures. Firm clay was encountered to a depth of 8.5 feet, followed by a layer of medium dense silty to clayey gravel extending to 13 feet at which depth the bank steepens to near vertical. Below 13 feet stiff silty and sandy clay with scattered gravel was encountered to about 26.5 feet with a clayey sand layer at 19 to 19.5 feet. From 26.5 to 31 feet, the unit grades from clayey, gravelly sand to a dense silty gravel. At 31 to 32.5 feet a stiff silty clay layer was found with distinct upper and lower contacts. From 32.5 to 35.5 feet a cohesionless fine to coarse sand with fine to coarse gravel was encountered. This gravel layer is highly erodable, and where exposed is readily undercut by the stream (Photograph 10, Figure 8).

Groundwater is generally encountered below 40 feet in this area, but the slopes along Dierickx Drive and Franklin Avenue have some moisture resulting from the use of septic tanks and leach fields, as shown on Strip Map 3. When wetted the subsurface materials are more susceptible to sliding.

The stream banks along much of this reach are very steep to vertical. Ten sections of this reach have been zoned as unstable (Nos. 12 through 21), with steep to vertical bluffs, often with debris at the base, and sparse to moderate groundcover (Photograph 7, Figure 7). The zones adjacent to Dierickx Drive and Franklin Avenue have been protected by placement of large sized rip-rap at about 1:1 slopes, which appears to be providing satisfactory protection (Photograph 8, Figure 7). North of Pastel Lane, in an area where the stream valley widens out, the east bank is vertical with talus debris at the base (Photograph 9, Figure 8). The stream has become incised here into a relatively flat floodplain. The stream channel is straight where it passes the trailer park, and the unstable zones are small with moderate groundcover.

The portions zoned moderately stable generally have slopes varying from 1:1 to 2:1, moderate to heavy groundcover and some evidence of older slides or debris falls.

Three areas were zoned as stable because there was no evidence of slide activity, the slopes ranged from about 1.5:1 to 2:1, and have good groundcover. The stable slope adjacent to the greenhouses has been partially covered by dumped loose soil.

Reach 4 - El Camino Real to Stevens Creek Freeway

Reach 4 of Stevens Creek is characterized by a fairly straight channel with gentle, open curves. Immediately north of El Camino Real the channel is approximately 36 feet deep with steep or vertical banks. North of this section, the channel gradually changes from 30 feet deep to less than 20 feet deep around Central Avenue. The stream banks are generally moderately sloping with some areas which are much steeper; the slopes generally have heavy groundcover with a few bare patches.

The soils adjacent to Reach 4 are the same Sorrento Gravelly Loam and Clay Loam encountered in Reaches 2 and 3. The exploratory borings along Stevens Creek Freeway indicate a gradual change in the soils. Near El Camino Real, the soils consist of loose to medium dense gravelly sands and silty sands which become denser with depth. There are also occasional layers of firm to stiff clayey silt here. Near Central Expressway the soils are mostly loose silty sand and firm silty clay to about 40 feet depth. Gradually, the silty sands with occasional gravel beds grade to medium dense and dense. In one of the borings groundwater was encountered at 47 feet, and at 52 feet a loose silty fine to medium sand layer about 8 feet thick was found.

There are six unstable zones along Reach 4 (Nos. 22 through 27). Immediately north of El Camino Real, both banks show some instability (No. 22). The west bank has an upper vertical side with loose talus at the base with scattered large rip-rap as partial protection (Photograph 11, Figure 9). The east bank is steep with loose soil and sparse to moderate groundcover, and a number of small slumps near the top of the bank. Between Yuba Avenue and the Alviso-Mountain View Road (No. 23), the banks have steep slopes at about 1:1, with moderate groundcover, and a number of small slumps in the upperpart of the slopes (Photograph 12, Figure 9). The concrete sack rip-rap is being undercut slightly here (Photograph 13, Figure 10). There are zones of instability on either side of Dana Avenue (No. 25) with a few recent slides near Dana Avenue (Photograph 14, Figure 10). The channel is fairly narrow here, about 30 feet deep with very steep to vertical sides, and generally has moderate to heavy groundcover with a few bare slopes. The soil around the footings under the Dana Avenue bridge is slowly being eroded away requiring remedial action (Photograph 15, Figure 11). North of the Central Expressway another area of instability (No. 27) with steep slopes was observed with moderate groundcover and a number of small slides (Photograph 16, Figure 11).

The zones of moderate stability generally have 1:1 to 2:1 slopes with moderate groundcover, and only scattered small slides or slumps. Several areas of concrete sack rip-rap near the Alviso-Mountain View interchange are being slightly undercut as the stream channel deepens. There are three areas of stable slopes in this area, generally at 2:1 inclinations with good groundcover.

Between Central Expressway and Stevens Creek Freeway, the height of the west bank has been increased with the placement of a recent dike. Tension cracks were observed on one 20 foot long section of the dike just south of Central Avenue.

Reach 5 - Stevens Creek Freeway to Bayshore Freeway

The entire length of Reach 5 has been channelized (Photograph 17, Figure 12) with the channel gently curved near Middlefield Road and then straight for the rest of the reach. The slopes are generally about 1:1 to 1.5:1, with moderate to heavy groundcover of grasses and vines.

The soils consist of a small area of Campbell Clay Loam at the south end of the Reach, and Mocho Clay Loam for most of Reach 5. Both soil types have moderate surface permeability.

The Middlefield Road bridge over Stevens Creek is underlain by firm to stiff silty clay interbedded with loose to medium dense silty sands. The sands and gravels grade denser with depth, and groundwater was encountered at 60 feet. In the area of Moffett Boulevard, the top 20 feet consist of firm to stiff silty clay underlain by loose to medium dense sands and gravels. Towards Bayshore Freeway, the area is underlain with soft to stiff silty clays with scattered thin beds of sand and silty sand.

With the exception of two small areas, all of Reach 5 has stable slopes. Some scattered small slides and surficial slumps were seen, however, and in the two areas classified as moderately stable, the slides are a little larger and closer together. Portions of the stream channel have been protected by concrete sack rip-rap and concrete slabs.

Reach 6 - Bayshore Freeway to Crittenden Lane

This reach is characterized by a straight, dredged channel with levees on both sides, Photographs 18 and 19, Figures 12 and 13. Near the freeway, the banks have a heavy groundcover of vines. The vegetation rapidly changes to scattered grasses and weeds, and just past the trailer park the vegetation changes to salt tolerant pickleweed.

The soils along this stretch consist of Mocho Clay Loam changing to Mocho Sandy Loam adjacent to the Moffett Field housing. Subsurface borings show the area to be underlain by soft to stiff silty and sandy clays with small amounts of gravel. Groundwater was encountered between 6 and 10 feet.

The channel sides are basically stable with one small area of moderate stability adjacent to the Moffett Field housing. Part of the east bank has been undercut and several small slumps have occurred. The levees north of the trailer park are in good condition with a few scattered burrows and minor cracking.

Reach 7 - Crittenden Lane to San Francisco Bay

Reach 7 is dredged along its entire length, with levees on either side. The original dredging was done in 1967, and Bay Mud was used to form the levees. The levees gradually sank due to a combination of consolidation of the Bay Mud and regional subsidence. In about 1975 the levees were raised to approximately 10 feet with imported fill.

The soil near Crittenden Lane is primarily Alviso Clay which is a saline or alkali soil with poor drainage. Beyond the sanitary landfill site, the area is primarily intertidal ponds.

The levees are in good condition with occasional burrows and tension cracks, Photograph 20, Figure 13. An examination of the levee slopes show a few areas where the slopes appear to bulge out such as cross-section at Sta. 375+20, Strip Map 6, possibly caused by settlement as a result of the additional fill that was placed in 1975 to raise the levees.

CONCLUSIONS AND RECOMMENDATIONS

In terms of geologic time there can be no permanent solution to the slope stability problems along Stevens Creek. Man can provide only a delaying action in the natural processes that are shaping the earth's surface.

One of the overall solutions to the slope stability problem is to develop a set of structural setbacks to be used for land planning purposes. The structural setback boundaries indicate the estimated limits of slope stability problems. The structural setbacks recommended in the study are based on the degree of existing slope stability. Category I slopes were assigned a 2.5:1 setback, Category II slopes were given 2:1, and Category III slopes were given a 2:1 setback. In addition, there is a need for a maintenance corridor in addition to the structural setback; an additional 23 feet is therefore added to the setback. The boundaries of each stability category are shown on the strip maps. The

Not Added In Final Report

horizontal distance of the setback varies with the depth of the channel and is measured from the base of the slope; the deeper the channel, the greater the horizontal setback.

The recommended structural setbacks should also be adequate during earthquakes with cyclic loading resulting from moderate to severe groundshaking. The Category I zones with very steep slopes would be susceptible to sliding triggered by groundshaking, particularly when the soils are saturated as during the rainy season. On the basis of limited but fairly representative subsurface information, the likelihood of liquefaction or lateral spreading appears to be minimal. In the area of the Central Expressway underpass, however, an 8 foot layer of loose, silty fine sand below the watertable at a depth of 52 feet is potentially liquefiable. With this one exception, the remaining borings indicated that any loose, silty sands were above the watertable and hence not subject to liquefaction.

Since the existing slope stability problems are related to natural erosion by the stream, little can be done to permanently stop the instability, although remedial measures can significantly improve stability. Protection of the toe of the slope from erosion is an important step however, and the use of large sized rip-rap placed at an approximate 1:1 slope has been successful in the past and has an aesthetic appearance.

The desire to keep Stevens Creek as natural as possible limits the types of remedial measures which can be used. With a few exceptions, most of the stream can be left unchanged without any large adverse effects in our opinion.

The slope stability in the area of Dierícx Drive, Franklin Avenue and Pastel Lane would be greatly improved if the use of septic tanks and leach fields near the creek were discontinued since saturated soils have less strength than dry soils. This in combination with protection of the toe of the slope from erosion and undercutting would greatly increase the stability of this section.

The channelized portions of Stevens Creek downstream from Middlefield Road reportedly do not have enough capacity for the 100 year flood. It is proposed to increase channel capacity by raising the existing levees and constructing new levees. Detailed investigation of the engineering properties of the levees and subsurface materials were not within the scope of this reconnaissance study and therefore we cannot determine the actual slopes that would be required for stability of raised dikes. We have evaluated the general stability and give the following values to assist in planning setbacks and right of ways. These values are the minimum setbacks since they represent the maximum slope that, in our opinion, could be anticipated to be stable, as shown on Strip Maps 5 and 6. Prior to final design and/or actual raising of these levees a subsurface exploration of the soft compressible Bay Mud is recommended in order to base the final slope inclinations on appropriate shear strength data.

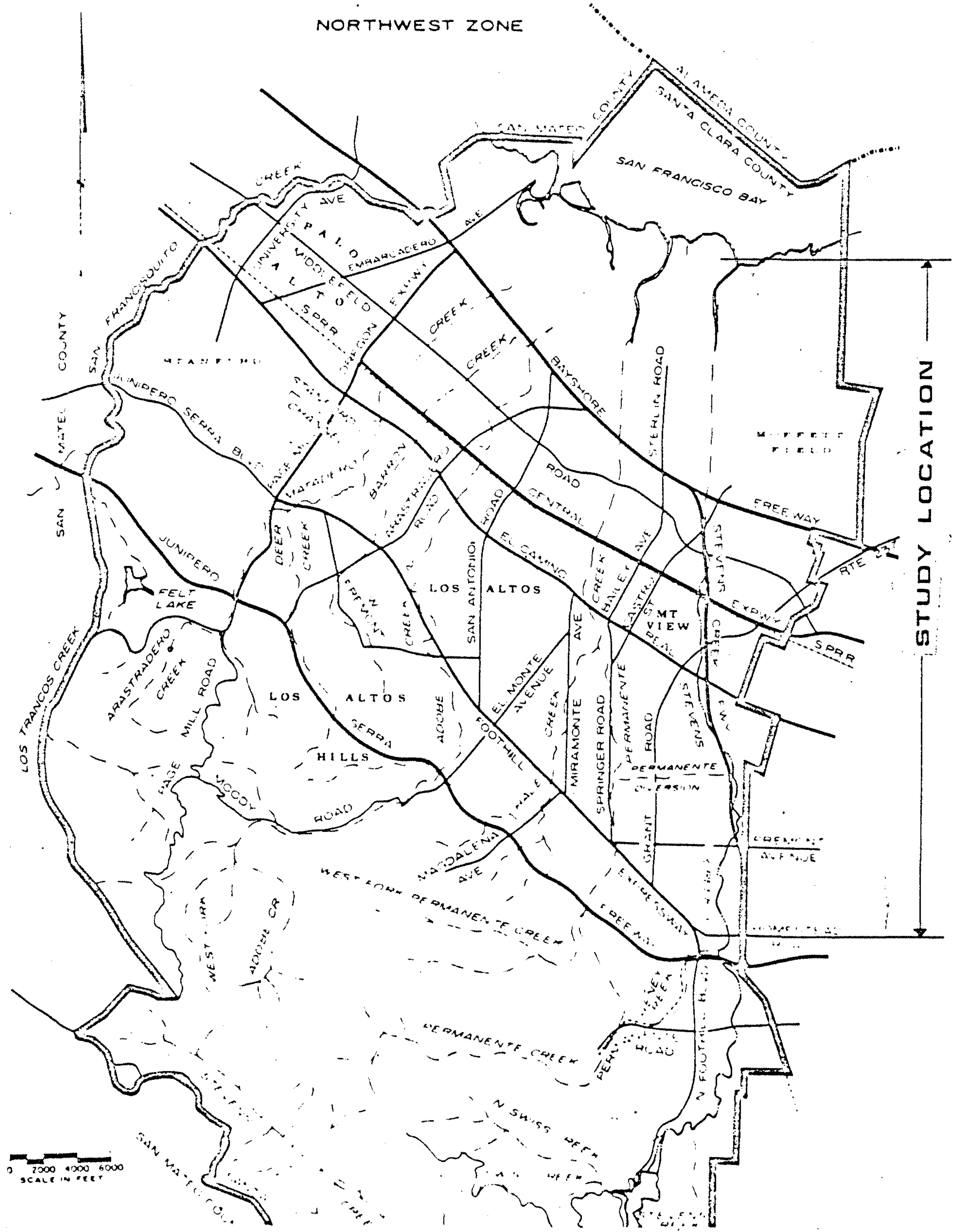
In the reach upstream of Bayshore Freeway, the slopes are sufficiently stable so that adding a few feet of dike soil should not be a problem as long as the slopes are no steeper than existing slopes. The existing levees downstream of Bayshore Freeway to about the south end of the trailer park should adequately support raised levees with slopes no steeper than 2.5:1. From the trailer park to Bayshore Park, the proposed levees should have slopes of 3:1, as shown in cross-sections on Strip Maps 5 and 6.

There are four Category 1 zones of instability which need immediate remedial action. The base of the slope in zone No. 1, Reach 1, should be protected from continued undercutting by placement of large sized rock rip-rap or other appropriate means.

The drop structure in Reach 2, zone No. 6, needs to be rebuilt, sidewall erosion should be controlled, and the natural slope on the outside curve just downstream needs to be protected from additional undercutting.

The slope just north of El Camino Real (No. 22) on the west side shows evidence of continuing instability which is encroaching on the maintenance corridor. Some large rip-rap has been placed at the base of the slope as a temporary measure, but more permanent remedial measures are needed. In addition, the concrete sack rip-rap protecting the nearby storm sewers is being undermined.

The slopes beneath the Dana Street bridge in zone No. 25 is being slowly eroded. The bare slopes need some protection such as armoring the slope with concrete sacks.



Base: Amended Planning Study for Stevens Creek, 1974, Santa Clara Valley Water District

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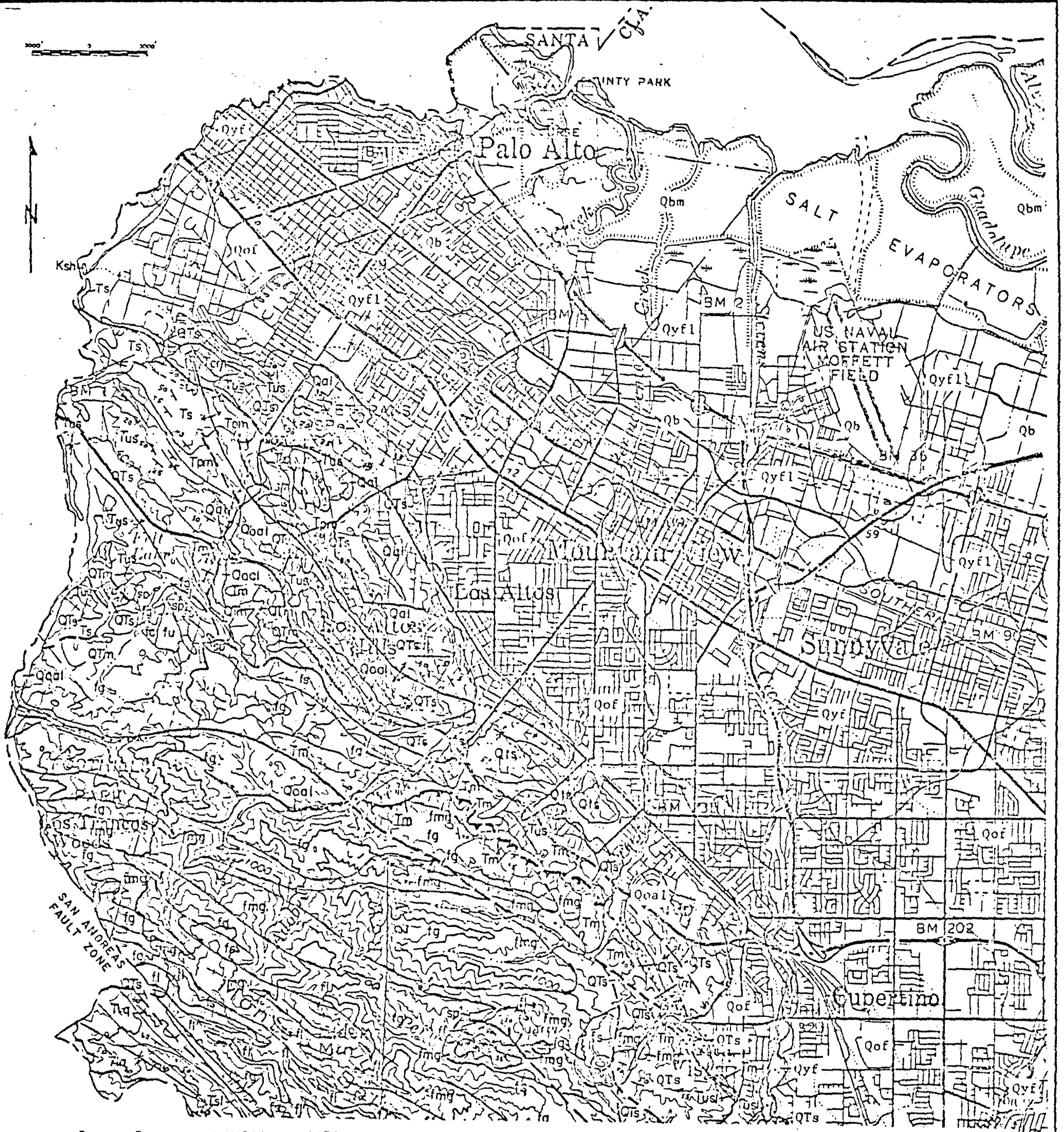
SITE PLAN

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	Figure 1
109-10	May 1978	



Base: Rogers and Williams, 1974, Geologic Map, Santa Clara County

Qyf	Young alluvial fan deposits: Fine-grained sand and silt, minor gravel.
Qyfl	Fluvial deposits at outer edge of alluvial fans: Fine-grained sand, silt, and clay.
Qb	Interfluvial fresh water basin deposits: Organic clay and silty clay; fossiliferous; subaerially weathered.
Qbm	*San Francisco Bay Mud:* Estuarine organic clay and silty clay; highly compressible; water content high, extremely variable.
Qoal	Older stream alluvium deposits.
Qof	Older alluvial fan deposits.
QTm	*Merced Formation:* Marine sandstone and siltstone; conglomeratic; locally fossiliferous (Pampeyan, 1970).
QTs	Nonmarine sedimentary rocks: Conglomerate, sandstone, siltstone, and claystone; locally fossiliferous (McLaughlin, 1974; Cummings, 1968). Includes *Santa Clara*, *Orinda*, and *Packwood Formations*.

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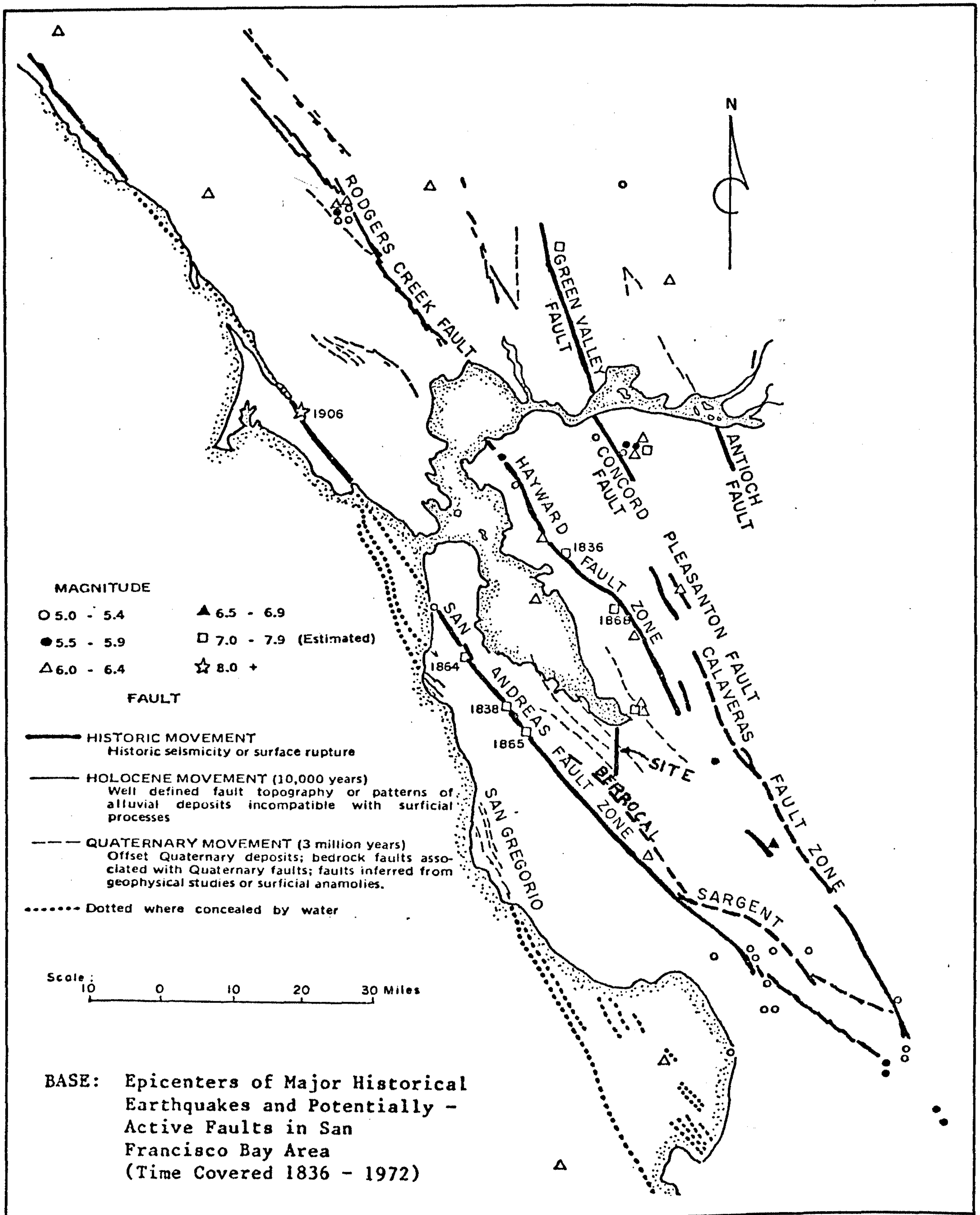
GEOLOGIC MAP

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	Figure 2
109-10	May 1978	


N
RODGERS CREEK FAULT
GREEN VALLEY FAULT
1906
HAYWARD FAULT ZONE
CONCORD FAULT
ANTIOCH FAULT
1836
PLEASANTON FAULT
1868
CALAVERAS FAULT ZONE
SAN ANDREAS FAULT ZONE
1864
1838
1865
SITE
BERROCAL
SAN GREGORIO
SARGENT
MAGNITUDE
○ 5.0 - 5.4
● 5.5 - 5.9
△ 6.0 - 6.4
▲ 6.5 - 6.9
□ 7.0 - 7.9 (Estimated)
☆ 8.0 +
FAULT
HISTORIC MOVEMENT
Historic seismicity or surface rupture
HOLOCENE MOVEMENT (10,000 years)
Well defined fault topography or patterns of alluvial deposits incompatible with surficial processes
QUATERNARY MOVEMENT (3 million years)
Offset Quaternary deposits; bedrock faults associated with Quaternary faults; faults inferred from geophysical studies or surficial anamolies.
Dotted where concealed by water
Scale:
10 0 10 20 30 Miles

BASE: Epicenters of Major Historical Earthquakes and Potentially - Active Faults in San Francisco Bay Area (Time Covered 1836 - 1972)

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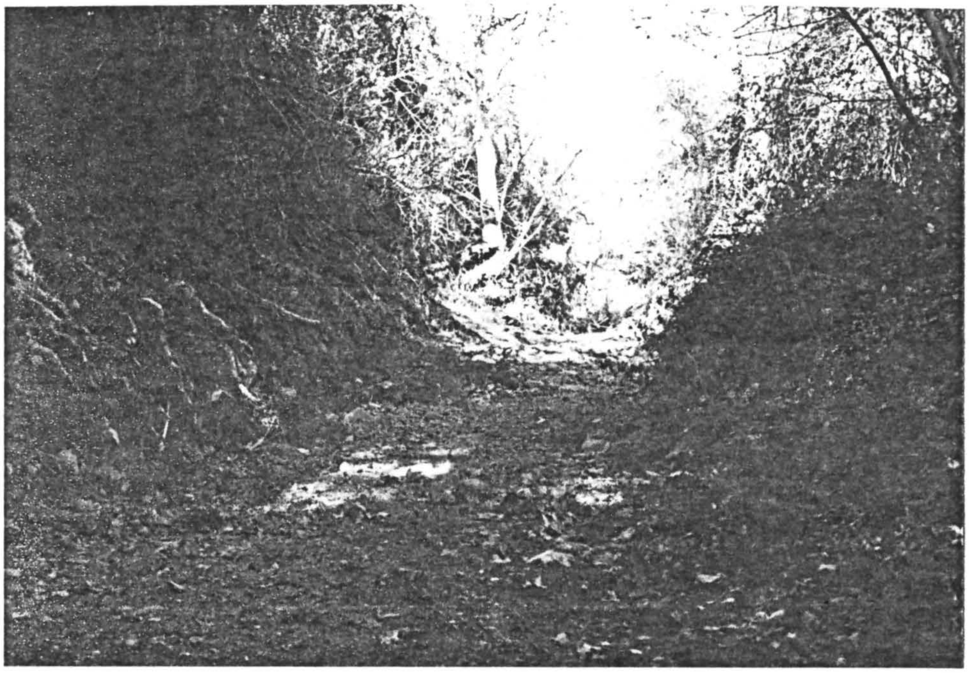
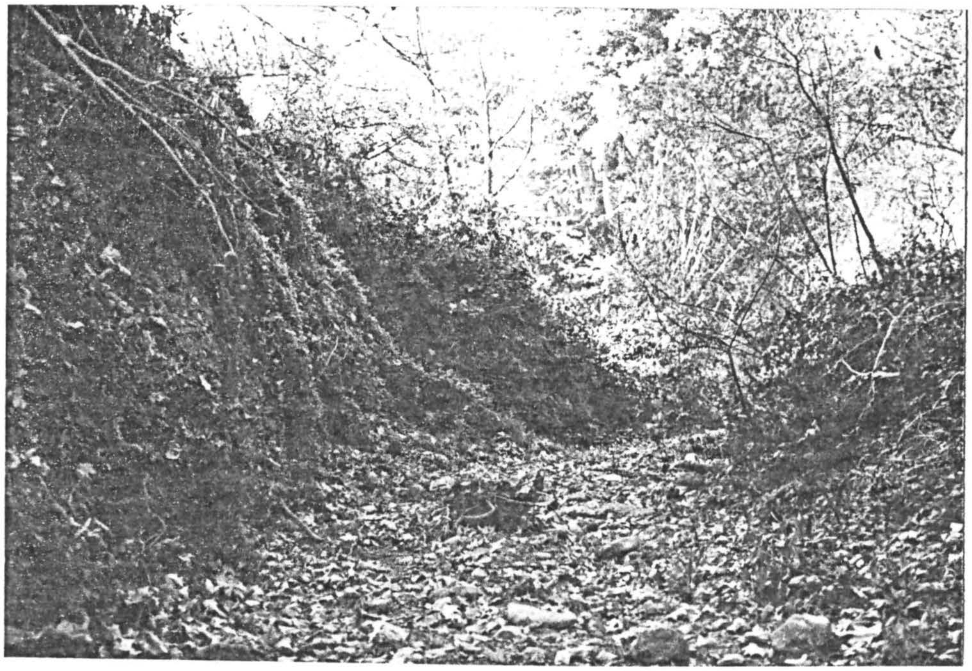
REGIONAL FAULT MAP

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	FIGURE 3
109-10	May 1978	



1. View downstream with 1:1 sloping banks and heavy vegetation. Reach 1.



2. View upstream with near vertical east bank and steep west bank. Stream channel slightly incised. Reach 1.

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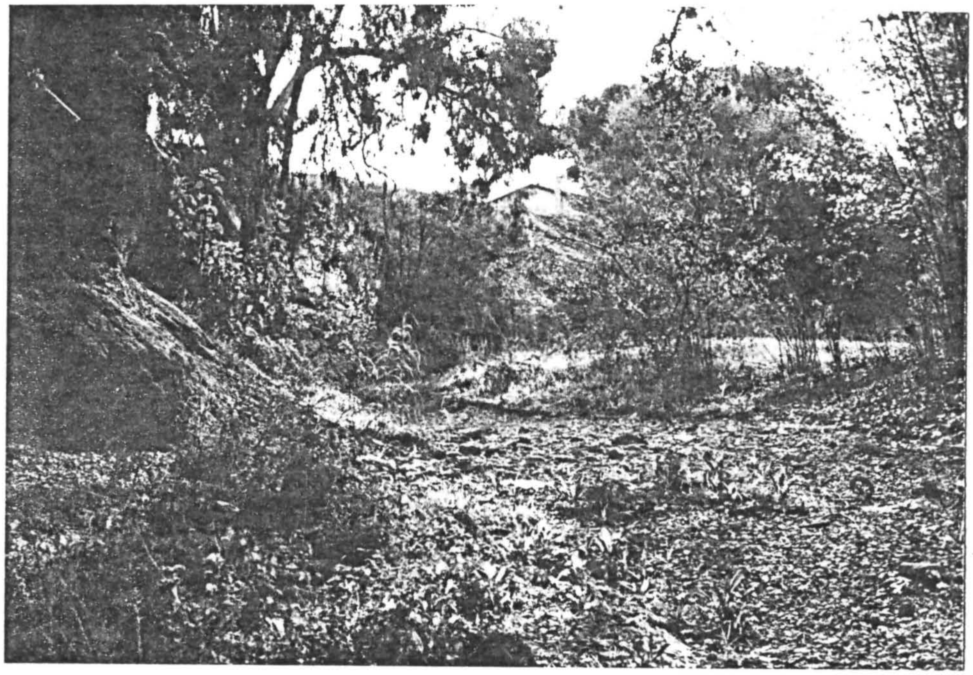
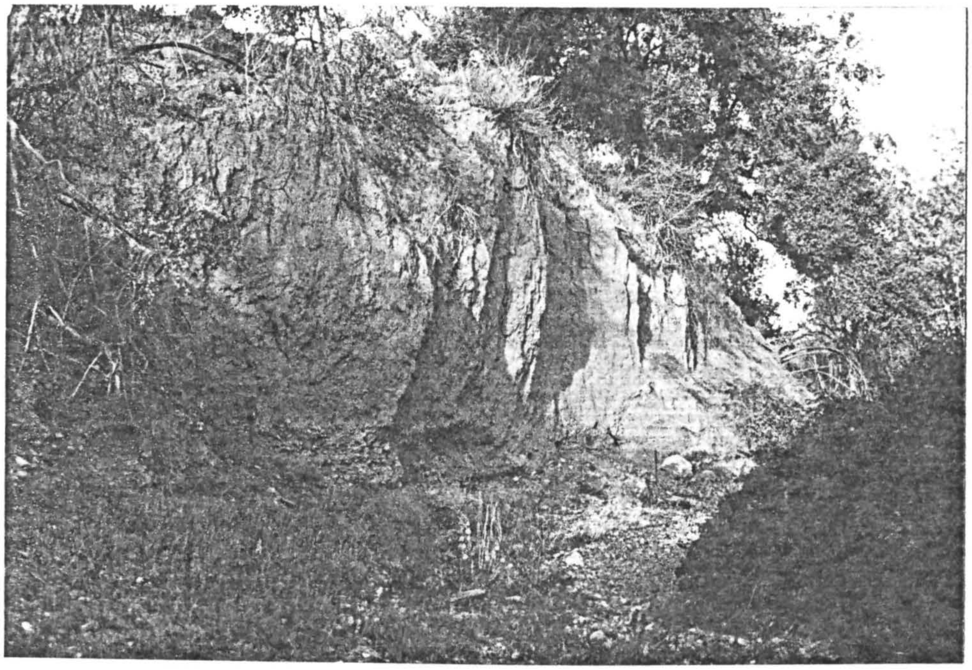
PHOTOGRAPHS

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	FIGURE 4
109-10	May 1978	

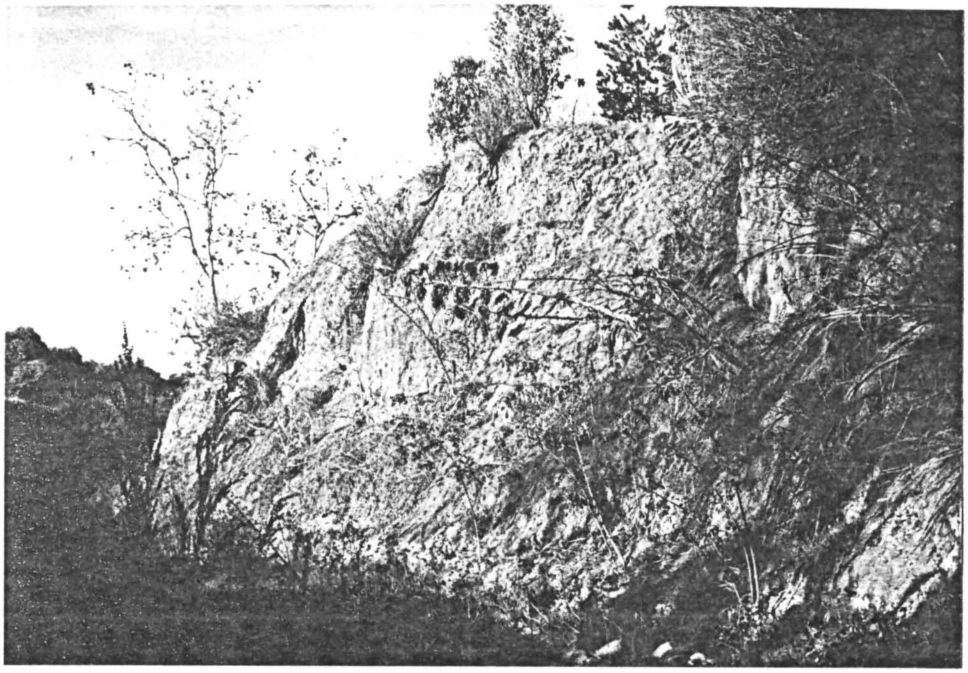


3. View upstream with a small flood plain and meander developed. Reach 1.

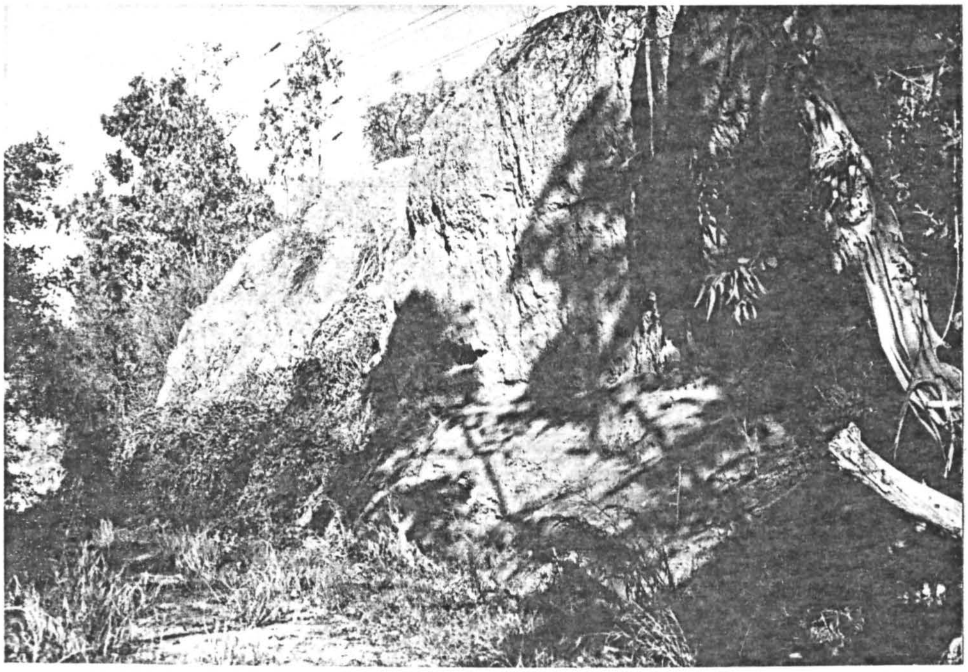


4. Vertical to undercut bluff on outside curve with an easily erodable sandy gravel layer at base. Reach 2.

John V. Lowney & Associates *Foundation / Soil / Geological Engineers*	PHOTOGRAPHS STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 5

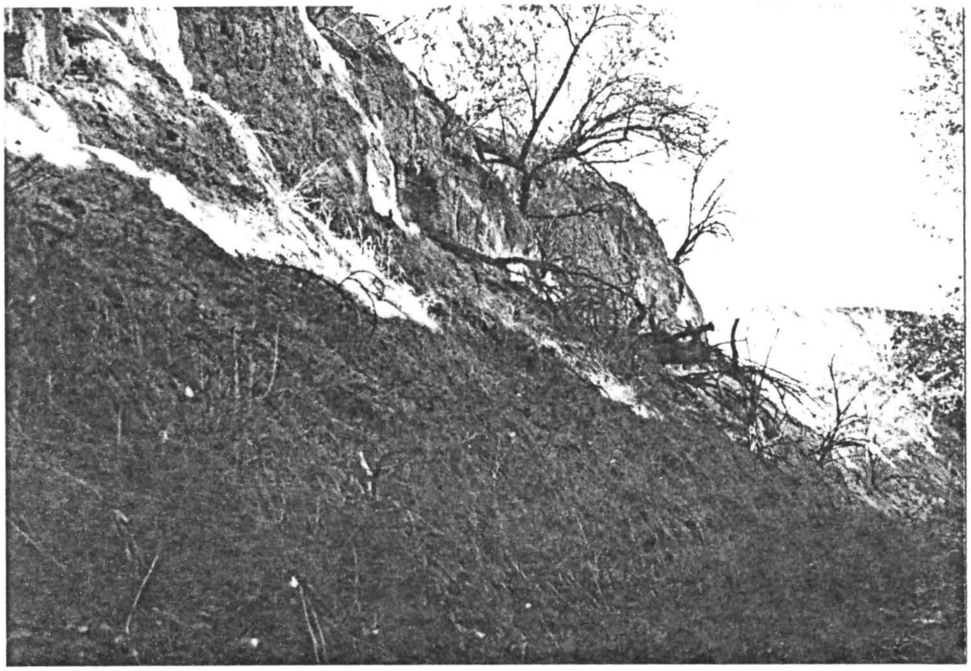


5. View of vertical bank with talus at base which is being eroded. Reach 2.

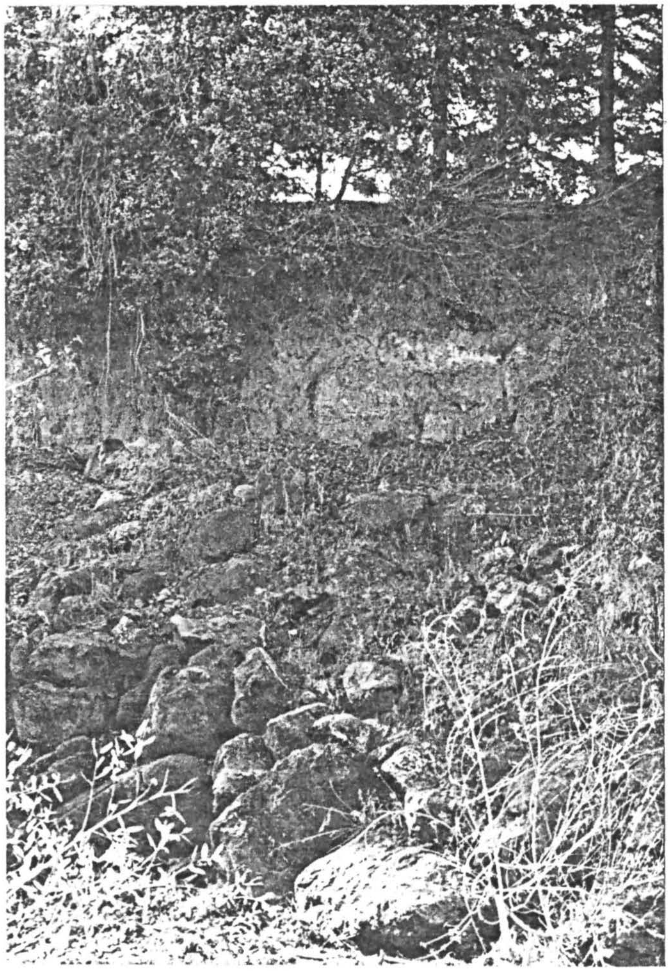


6. Slightly undercut bluff with talus at base. Note thin gravel layer which is easily eroded. Reach 2.

John V. Lowney & Associates *Foundation / Soil / Geological Engineers*	PHOTOGRAPHS STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 6

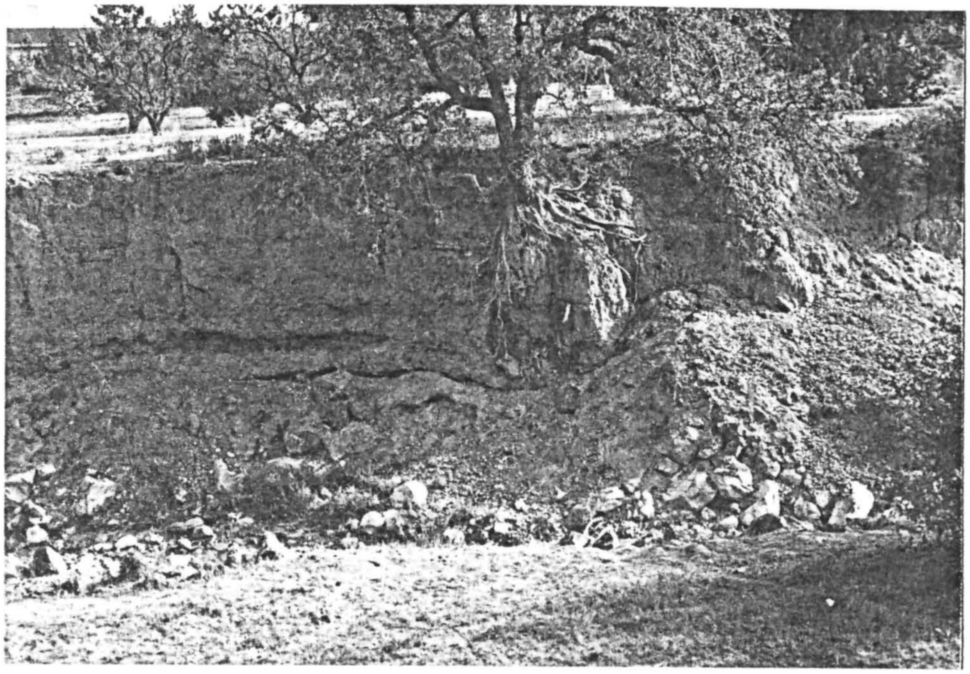


7. Vertical scarp above large talus slope. Toe of slope is being eroded Reach 3.

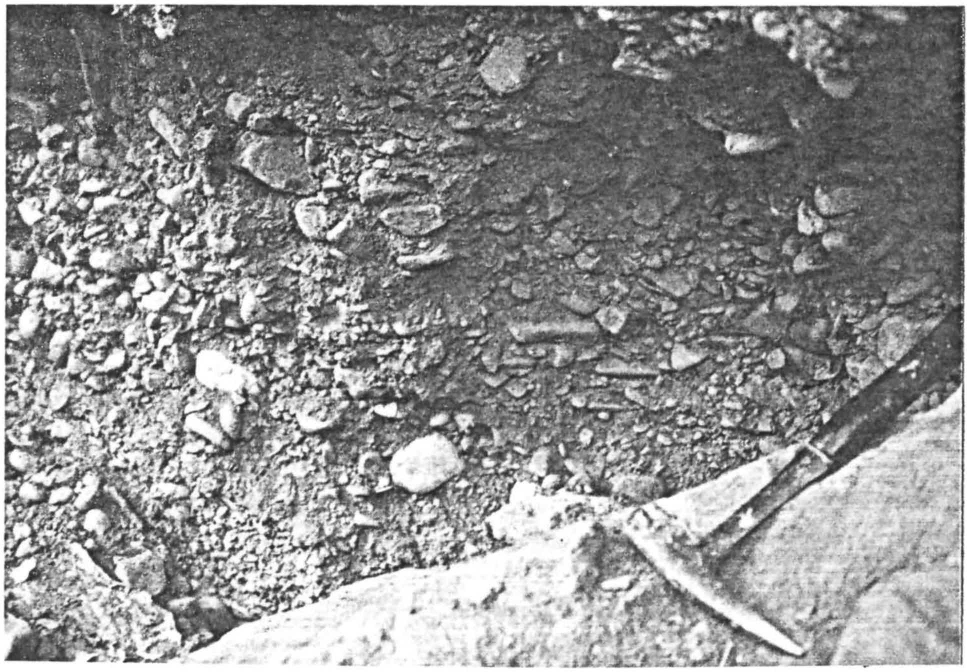


8. Larger vertical scarp from a recent slide above 1:1 rip-rap slope. Reach 3.

John V. Lowney & Associates *Foundation / Soil / Geological Engineers*	PHOTOGRAPHS		
	STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 7

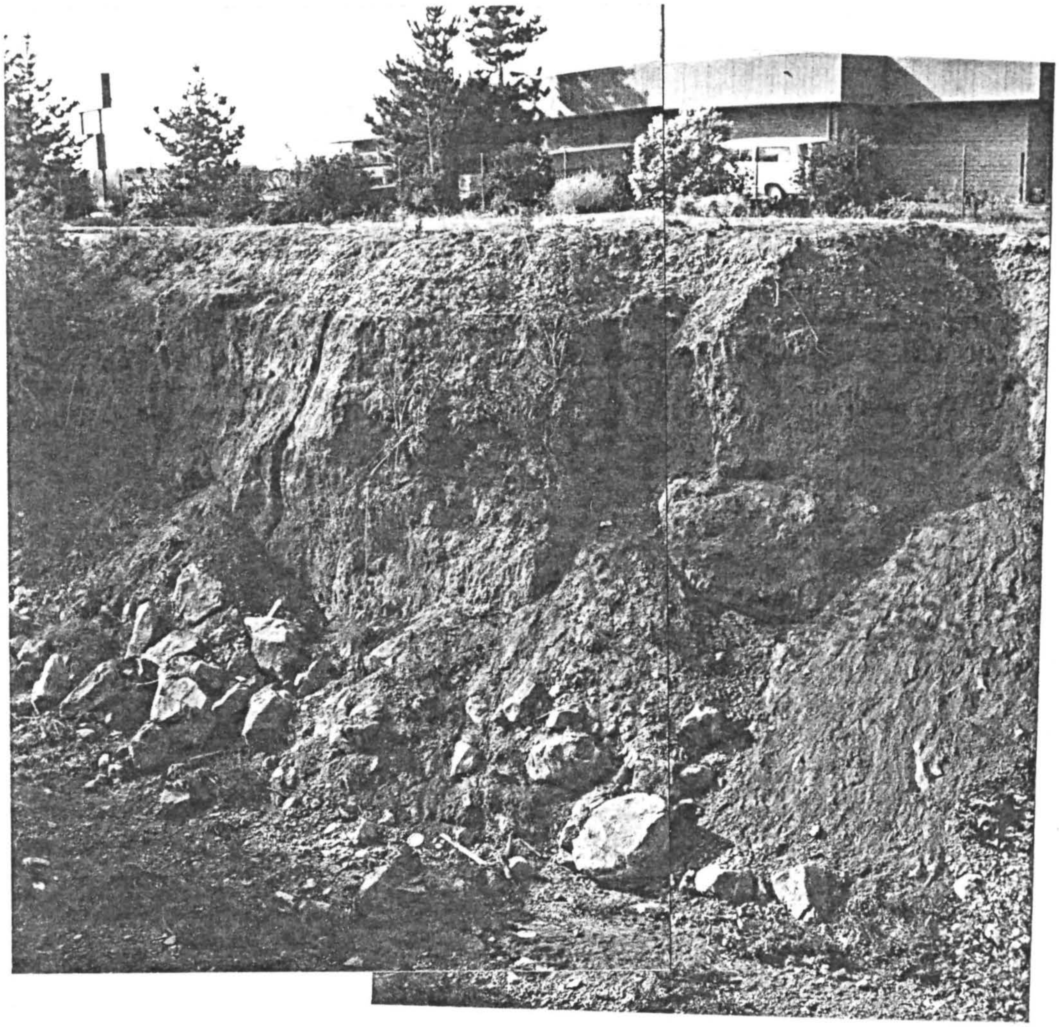


9. View of slides with vertical scarps above talus and rip-rap. Reach 3.



10. Closeup of erodable sandy gravel. Reach 3.

John V. Lowney & Associates *Foundation / Soil / Geological Engineers*	PHOTOGRAPHS STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 8



11. View of vertical slope with talus and rip-rap at base. Reach 4.

12. Small slide with vertical scarp. Reach 4.

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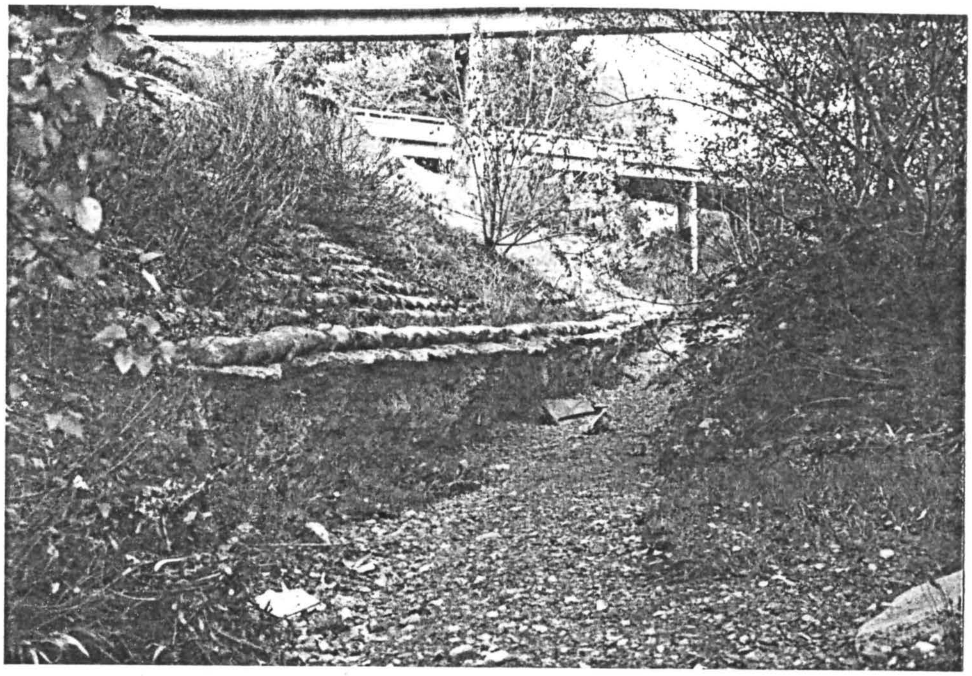
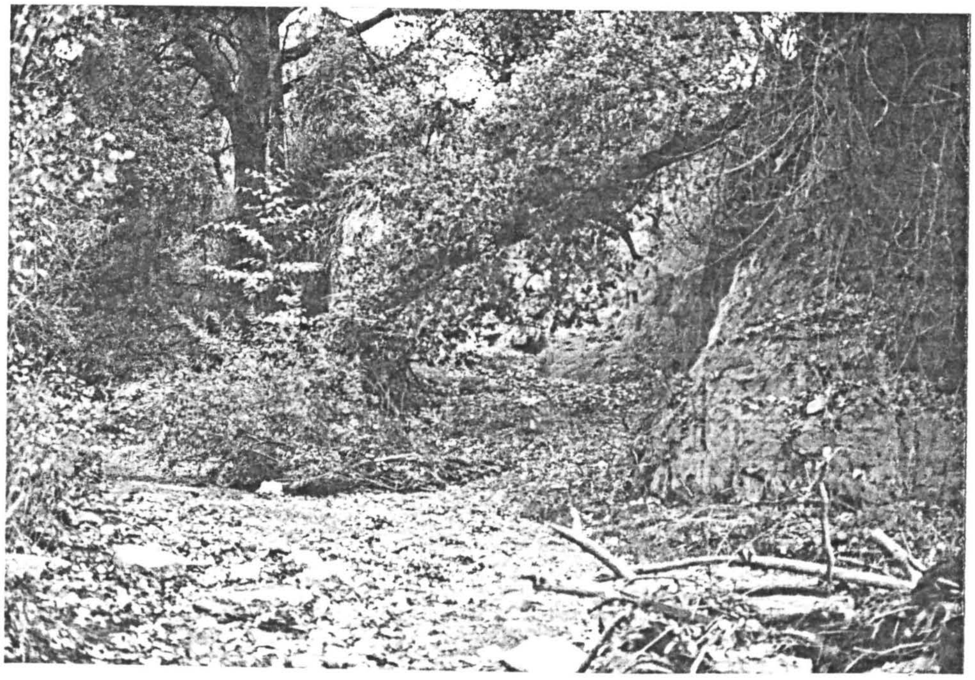
	STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 9



13. Undercutting of concrete sack rip-rap. Reach 4.



14. View of large slump with vertical scarp. Reach 4.

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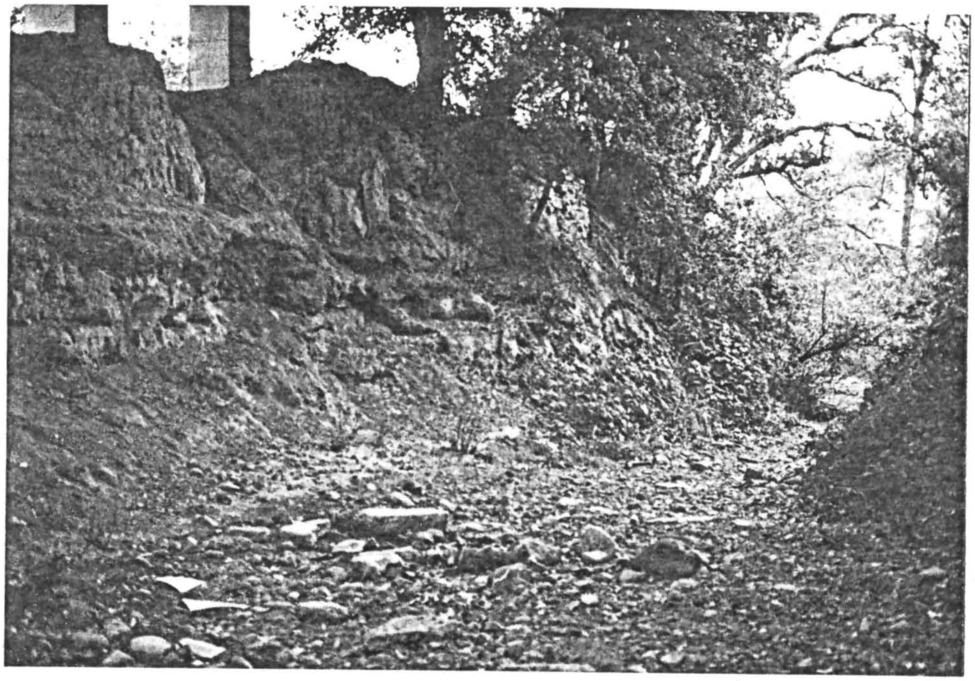
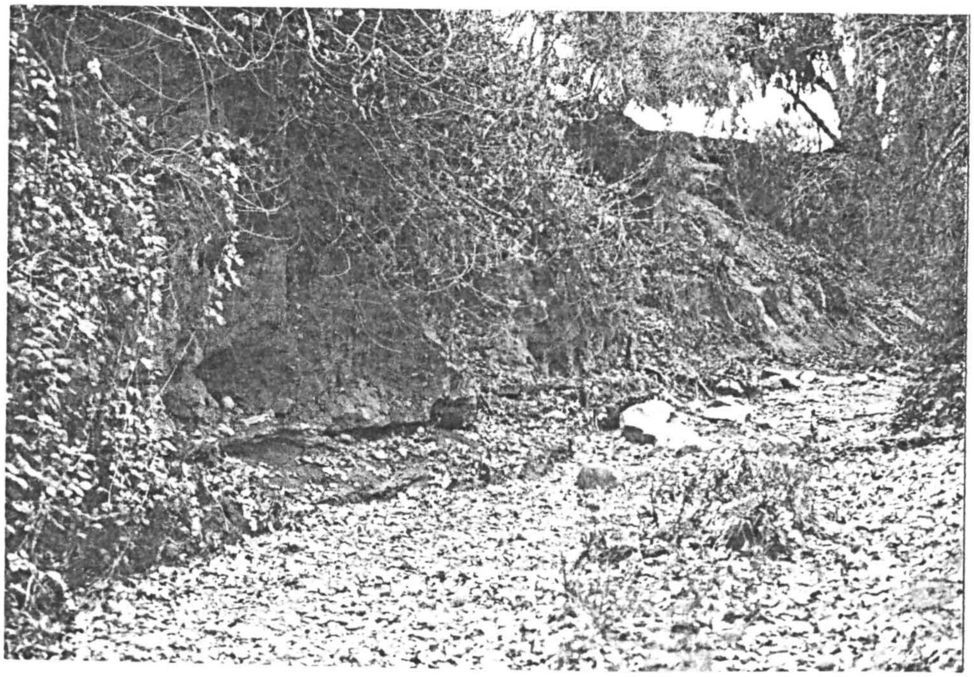
PHOTOGRAPHS

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	FIGURE 10
109-10	May 1978	



15. View of Dana Avenue bridge abutments showing steep, eroding slope. Reach 4.



16. View of undercut vertical bank on outside curve.

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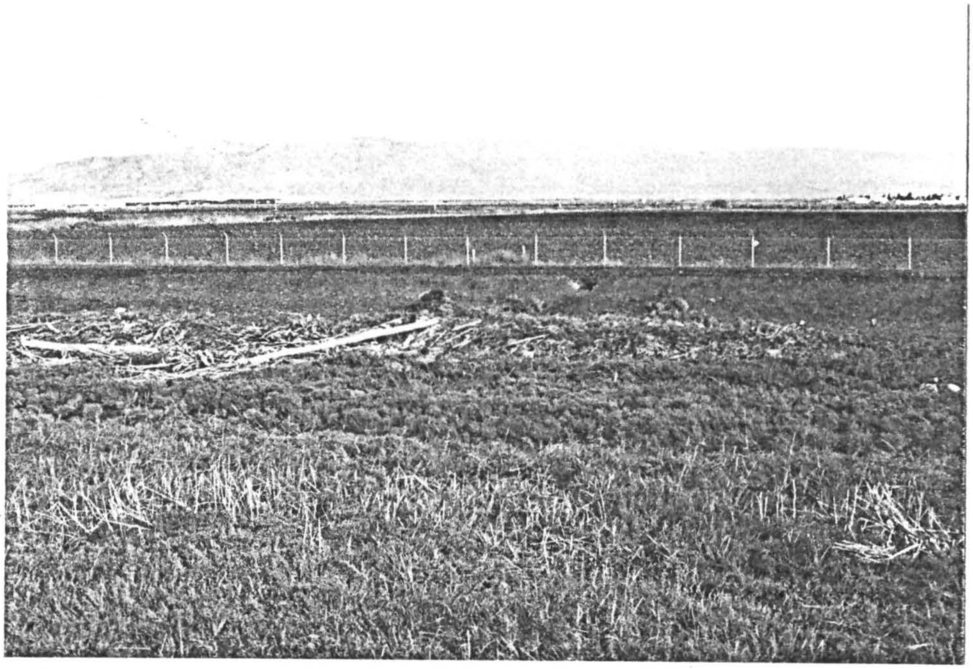
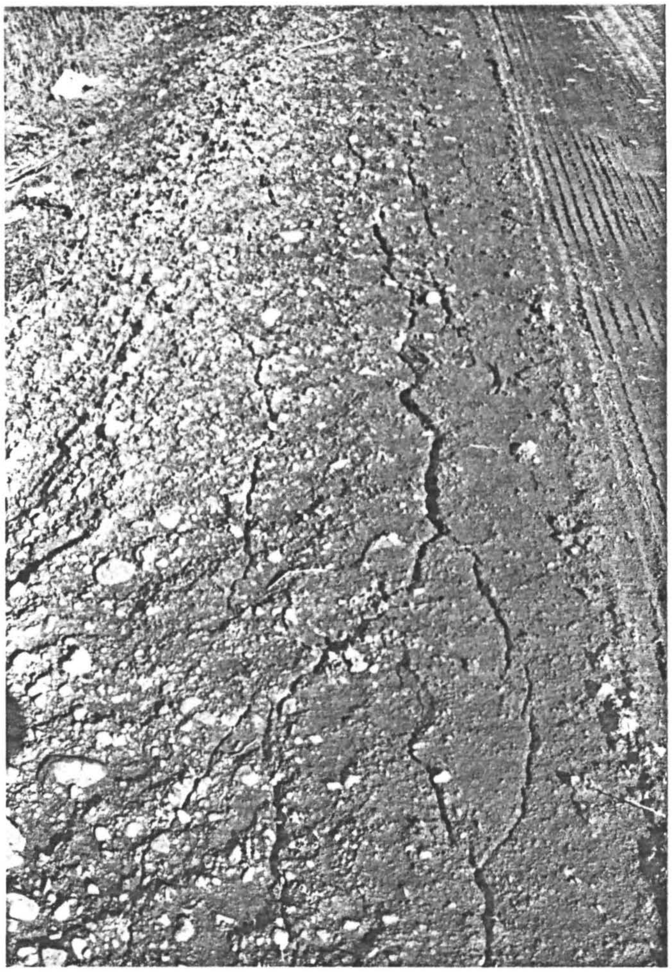
	STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 11

17. View of channelized section of creek. Reach 5.

18. View of levees and Crittenden Lane Bridge. Reach 6.

John V. Lowney & Associates *Foundation / Soil / Geological Engineers*	PHOTOGRAPHS		
	STEVENS CREEK San Francisco Bay to Homestead Road		
	PROJECT NO. 109-10	DATE May 1978	FIGURE 12





19. East levee with burrows. Reach 6.

20. Closeup of levee with tension cracks along inboard edge. Reach 7.

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PHOTOGRAPHS

STEVENS CREEK
San Francisco Bay to Homestead Road

PROJECT NO.	DATE	FIGURE 13
109-10	May 1978	

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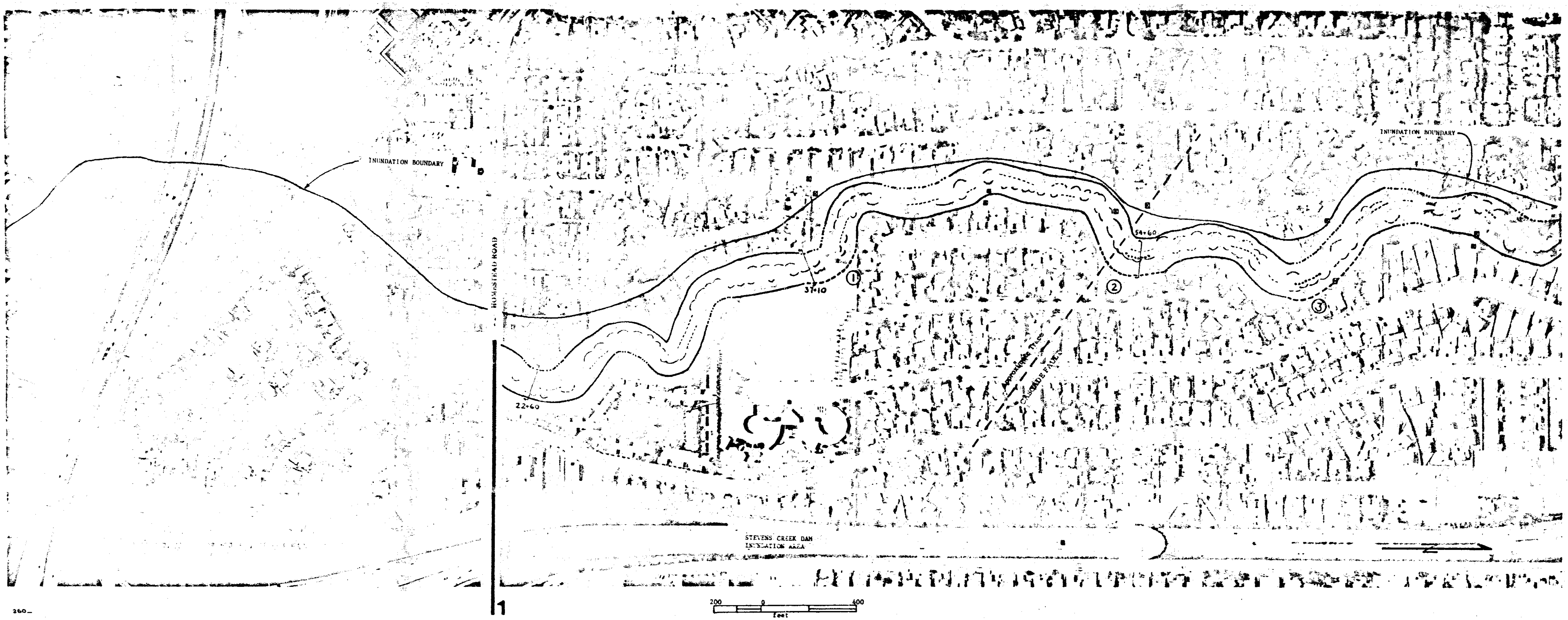
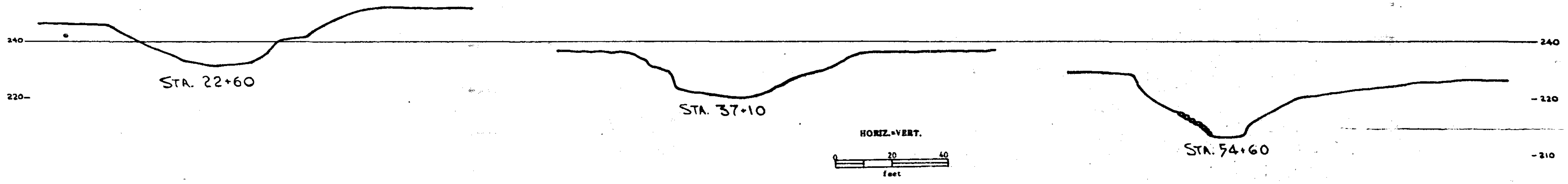




LEGEND

- - - - Category I - Least stable slopes
—— Category II - Moderately stable slopes
-·-·-· Category III - Most stable slopes
▨ Category IV - Man-made structures
◠ Scarp of recent slide or slump
◠ Scarp of older slide or slump
- - - - Incised stream channel
······ Tension cracks
●●●●● Rip-rap

② Numbering system of unstable zones referred to in text.

REV	DESCRIPTION	SUB	APPR

REFER TO TRACING FOR LATEST REVISION

REFERENCE INFORMATION AND NOTES

Inundation Boundary line from Inundation Map of Stevens Creek Dam, 1973, Santa Clara County Flood Control and Water District.

Date of Photography : 1-28-77

John V. Lowney & Associates

Foundation / Soil / Geological Engineers

DATE

DESIGN

DRAWN

CHECKED

Santa Clara Valley Water District

DESIGNED AND DRAWN BY

ACCEPTED BY DISTRICT

PROJECT ENGINEER R.C.E. NO.

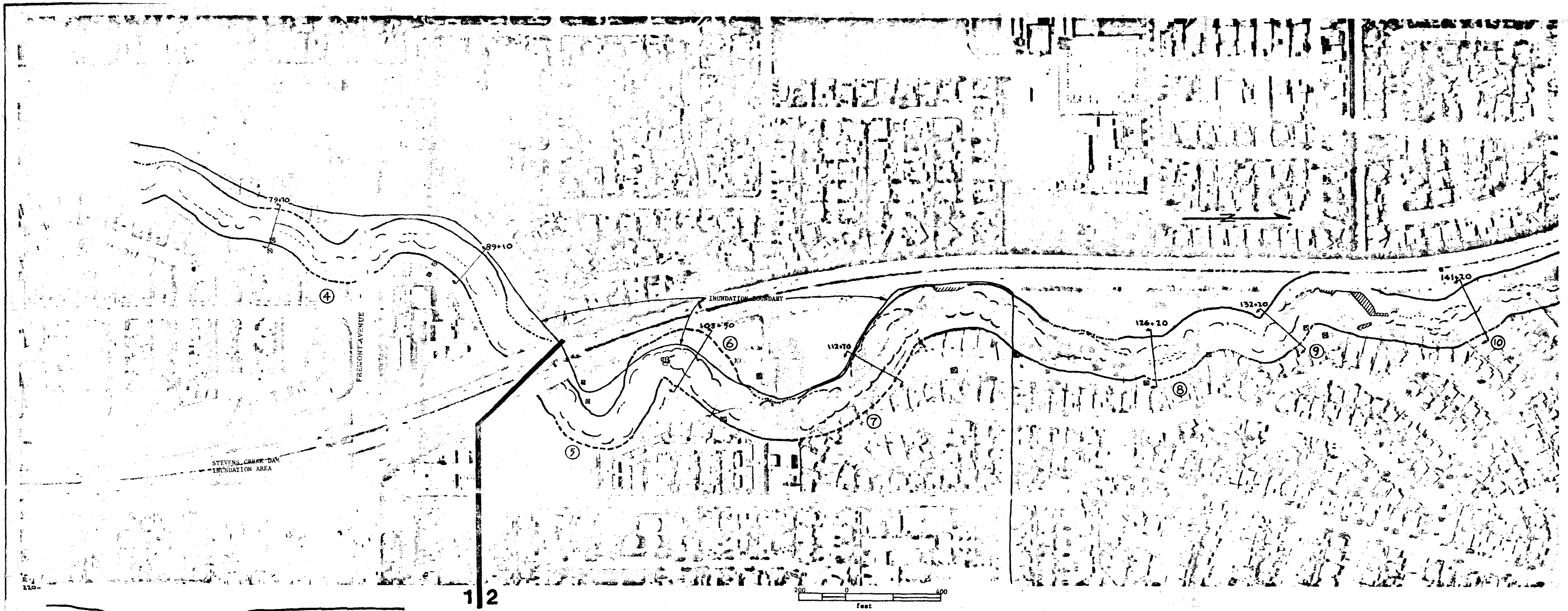
R.C.E. NO.

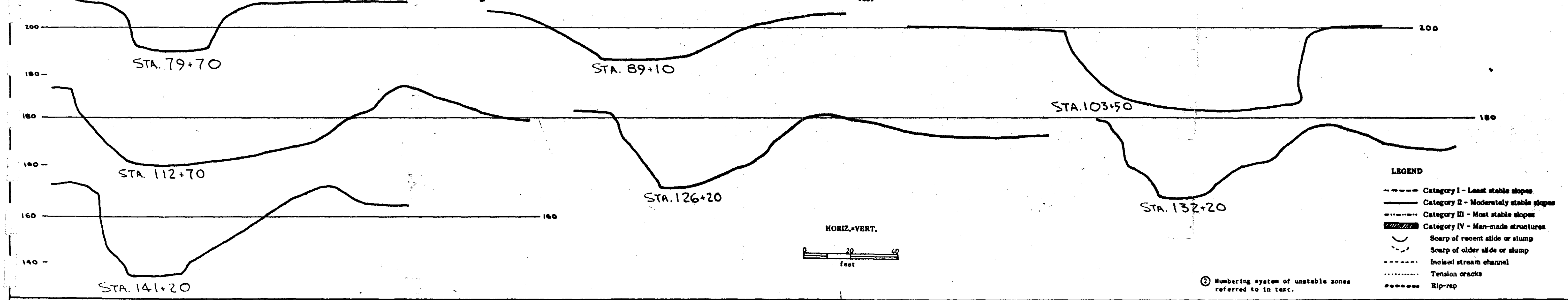
GENERAL PLAN

STEVENS CREEK

SCALE AS SHOWN

SHEET 1





LEGEND

- - - - -	Category I - Least stable slopes
———	Category II - Moderately stable slopes
-··-··-	Category III - Most stable slopes
▨	Category IV - Man-made structures
◡	Scarp of recent slide or slump
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- - - - - - -	Incised stream channel
···········	Tension cracks
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and Water District.

Date of Photography: 1-28-77

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DATE

DESIGN

DRAWN

CHECKED

Santa Clara Valley Water District

DESIGNED AND
DRAWN BY

ACCEPTED BY DISTRICT

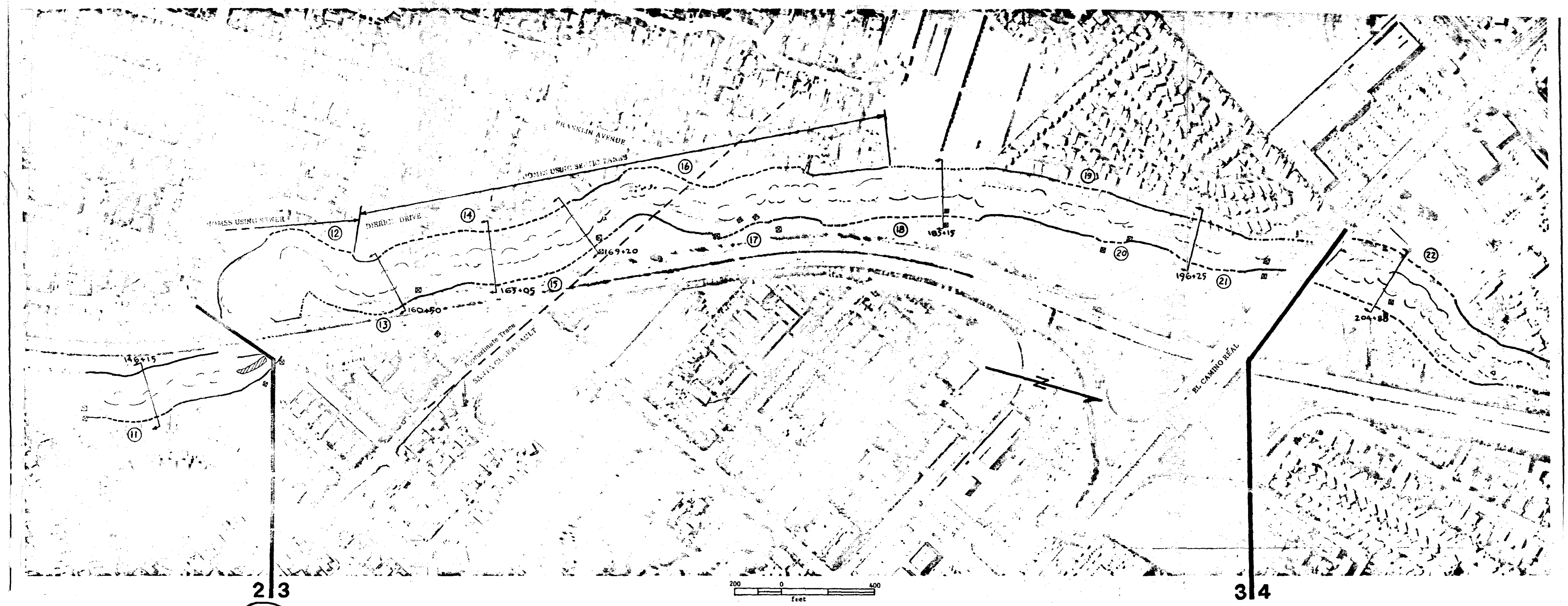
PROJECT ENGINEER R.C.E. NO R.C.E. NO

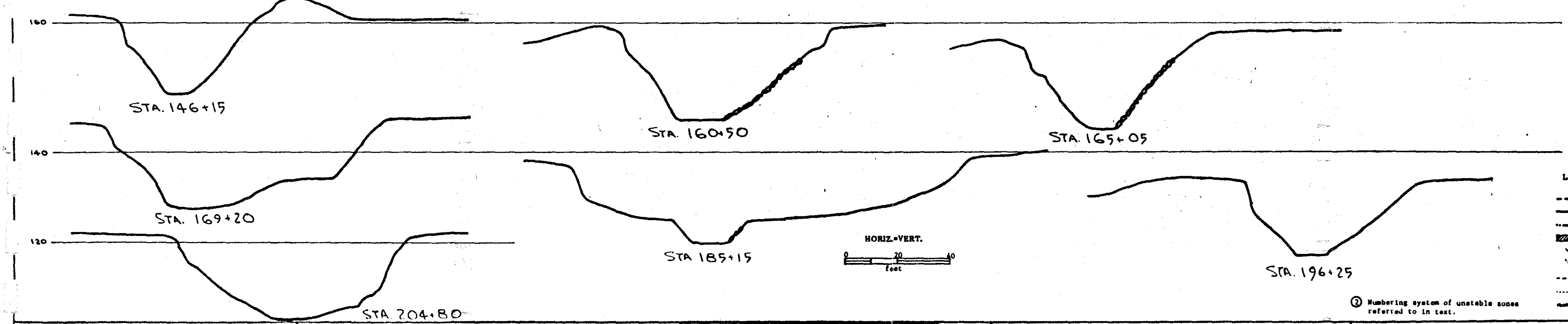
GENERAL PLAN

STEVENS CREEK

SCALE
AS SHOWN

SHEET
2





② Numbering system of unstable zones referred to in text.

LEGEND

- - - - - - Category I - Least stable slopes
———— Category II - Moderately stable slopes
·—·—·— Category III - Most stable slopes
▨ Category IV - Man-made structures
◡ Scarp of recent slide or slump
◡ Scarp of older slide or slump
- - - - - - Incised stream channel
·········· Tension cracks
〰 Rip-rap

REFER TO TRACING FOR LATEST REVISION			
REV	DESCRIPTION	SUB	APPR

REFERENCE INFORMATION AND NOTES

Date of Photography: 1-28-77

John V. Lowney & Associates

Foundation / Soil / Geological Engineers

DATE
DESIGN
DRAWN
CHECKED

Santa Clara Valley Water District

DESIGNED AND DRAWN BY

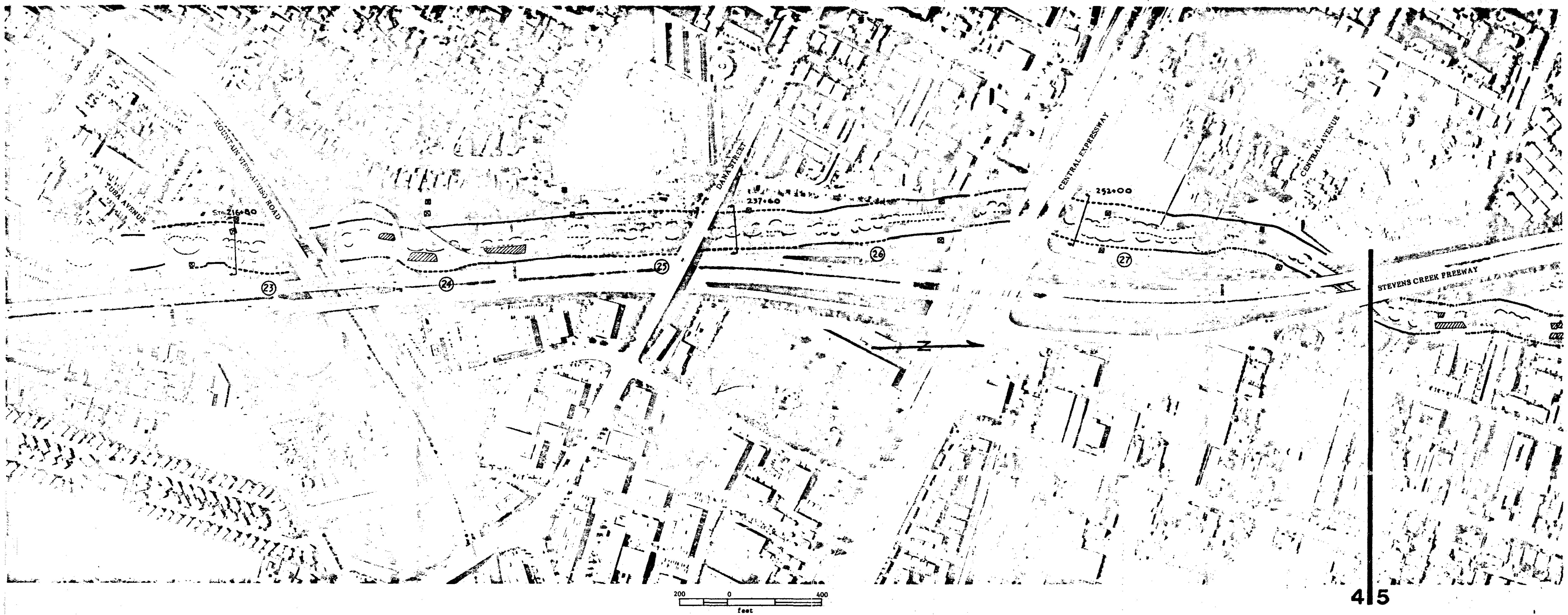
PROJECT ENGINEER R.C.E. NO

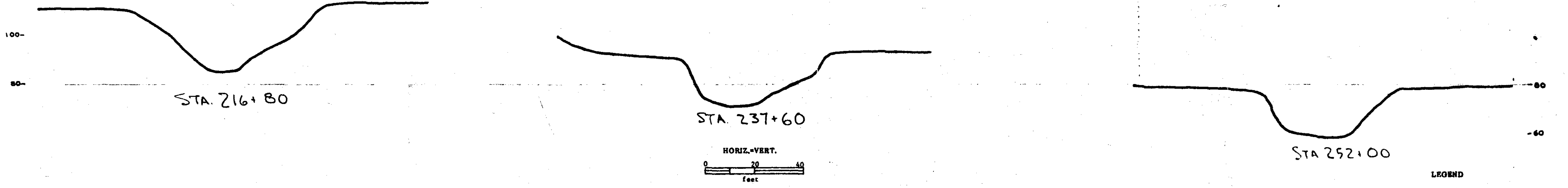
ACCEPTED BY DISTRICT R.C.E. NO

GENERAL PLAN
STEVENS CREEK

SCALE
AS SHOWN

SHEET
3





LEGEND

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—··—··—	Category III - Most stable slopes
▨	Category IV - Man-made structures
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- - - - - -	Incised stream channel
··········	Tension cracks
○○○○	Rip-rap

② Numbering system of unstable zones referred to in text.

REFER TO TRACING FOR LATEST REVISION		
DESCRIPTION	SUB	APPR

REFERENCE INFORMATION AND NOTES

Date of Photography: 1-28-77

John V. Lowney & Associates

Foundation / Soil / Geological Engineers

DATE

DESIGN

DRAWN

CHECKED

Santa Clara Valley Water District

DESIGNED AND DRAWN BY:

PROJECT ENGINEER R.C.E. NO

ACCEPTED BY DISTRICT

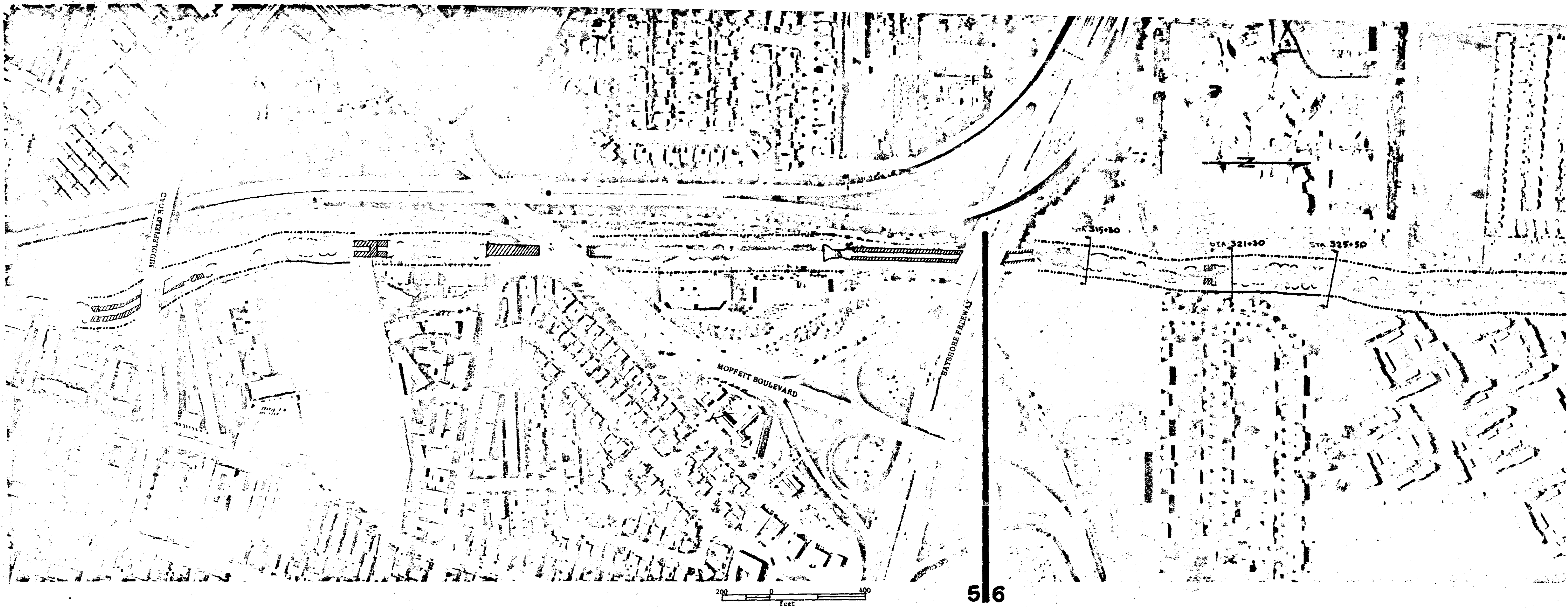
R.C.E. NO

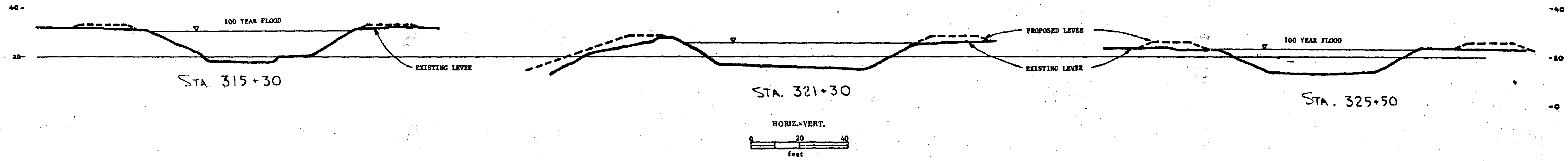
GENERAL PLAN

STEVENS CREEK

SCALE AS SHOWN

SHEET 4





LEGEND

- ‐ ‐ ‐ ‐ Category I - Least stable slopes
- ——— Category II - Moderately stable slopes
- ‐·‐·‐ Category III - Most stable slopes
- ▨ Category IV - Man-made structures
- ◡ Scarp of recent slide or slump
- ◡ Scarp of older slide or slump
- ‐‐‐‐‐‐‐‐ Incised stream channel
- ········ Tension cracks
- ○○○ Rip-rap

REV.	DESCRIPTION	SUB	APPR
REFER TO TRACING FOR LATEST REVISION			

REFERENCE INFORMATION AND NOTES

Date of Photography: 1-28-77

John V. Lowney & Associates

Foundation / Soil / Geological Engineers

DATE

DESIGN

DRAWN

CHECKED

Santa Clara Valley Water District

DESIGNED AND DRAWN BY

PROJECT ENGINEER R.C.E. NO.

ACCEPTED BY DISTRICT

R.C.E. NO.

GENERAL PLAN

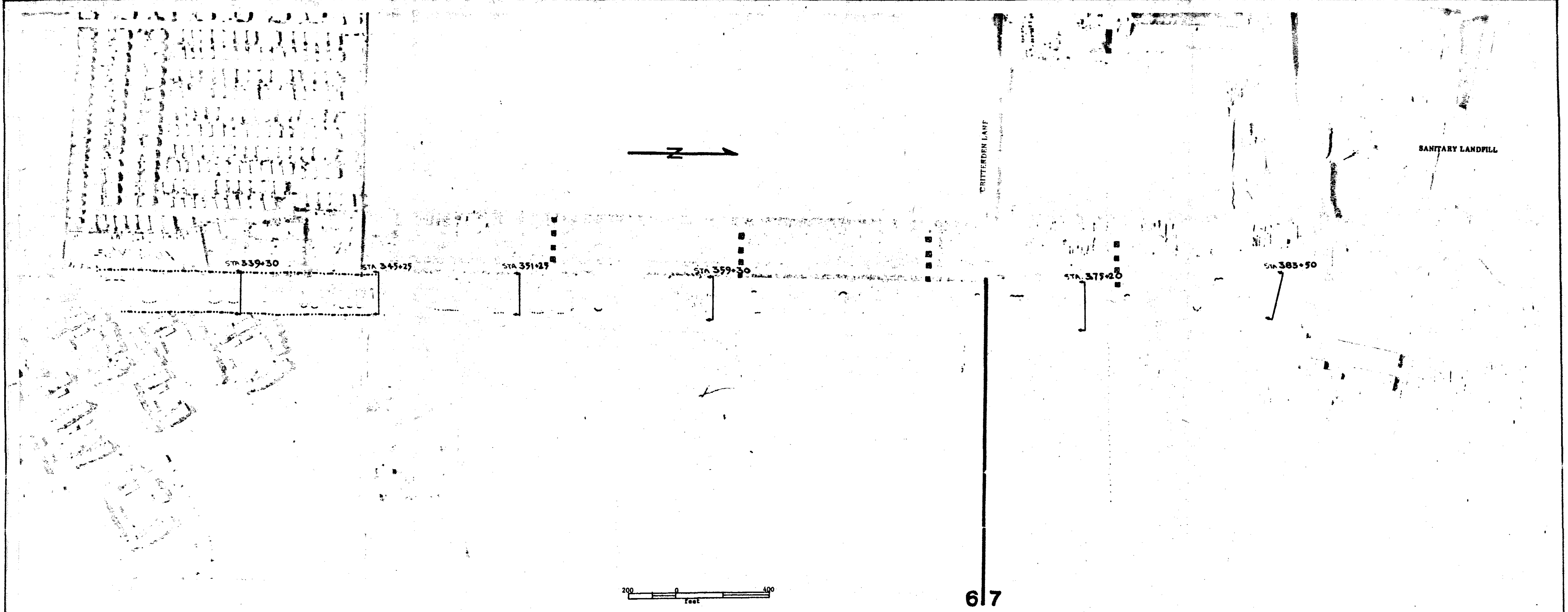
STEVENS CREEK

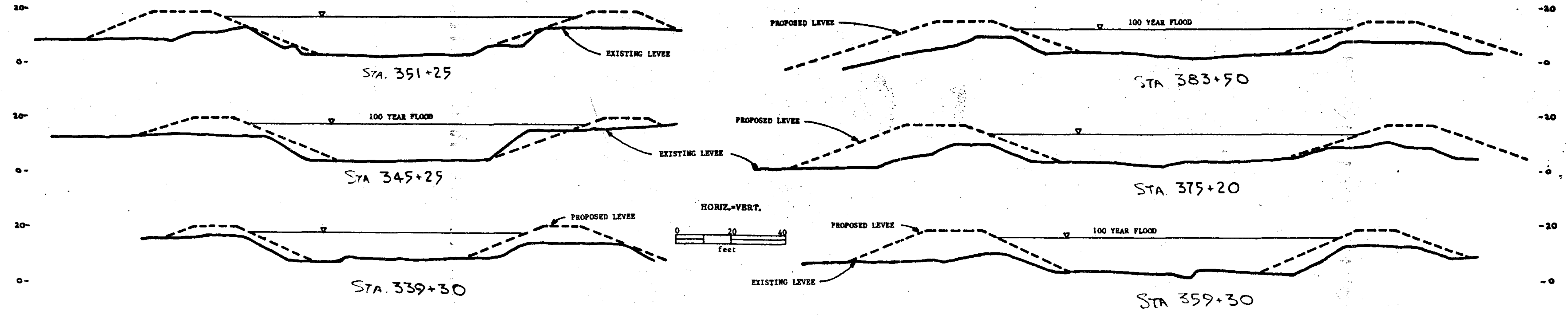
SCALE

AS SHOWN

SHEET

5





LEGEND

- - - - - - Category I - Least stable slopes
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-·-·-·- Category III - Most stable slopes
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◡ Scarp of recent slide or slump
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REFER TO TRACING FOR LATEST REVISION			
REV	DESCRIPTION	SUB	APPR

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PROJECT ENGINEER R.C.E. NO

ACCEPTED BY DISTRICT

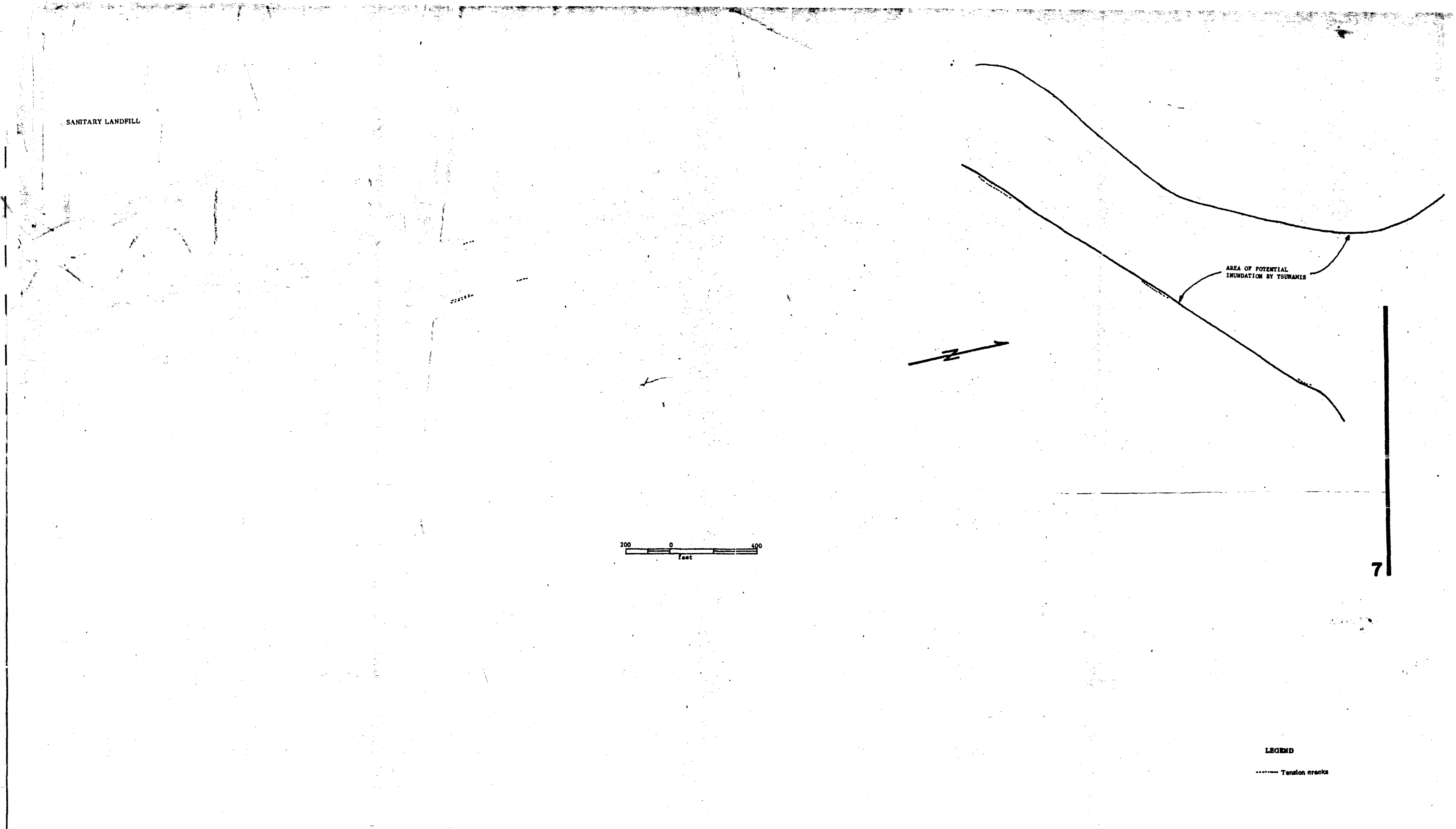
R.C.E. NO

GENERAL PLAN

STEVENS CREEK

SCALE
AS SHOWN

SHEET
6



REFER TO TRACING FOR LATEST REVISION			
REV	DESCRIPTION	SUB	APPR

REFERENCE INFORMATION AND NOTES

Date of Photography: 1-28-77

John V. Lowney & Associates

Foundation / Soil / Geological Engineers

DATE	
DESIGN	Santa Clara Valley Water District
DRAWN	DESIGNED AND DRAWN BY
CHECKED	PROJECT ENGINEER R.C.E. NO. — ACCEPTED BY DISTRICT R.C.E. NO.

GENERAL PLAN

STEVENS CREEK

SCALE AS SHOW

SHEET 7